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PHYSIOLOGY

OF THE

FŒTUS, LIVER, AND SPLEEN.

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THE
PHYSIOLOGY
OF THE
FŒTUS, LIVER, AND SPLEEN.

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PRESIDENT OF THE ROYAL PHYSICAL SOCIETY OF EDINBURGH;
LECTURER ON PHYSIOLOGY, AND JOINT LECTURER ON THE PRACTICE OF PHYSIC
IN THE SHEFFIELD MEDICAL INSTITUTION.

> We have but one simple way left us, and that is, leading mankind to particulars, their senses, and their orders; whilst they prevail upon themselves to forsake their notions for a time, and begin their acquaintance with things.—Nov. Org. Part I. Sect. I. Aph. xxxvi.
>
> Truth has been my only aim; and wherever that has appeared to lead, my thoughts have impartially followed.—Locke, B. 1, Ch. IV.

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THE INDEPENDENCE

WITH WHICH HE HAS CULTIVATED, AND PROMOTED

THE ADVANCEMENT OF MEDICAL SCIENCE,

THIS WORK

IS INSCRIBED, WITH EVERY SENTIMENT OF RESPECT,

BY THE AUTHOR.

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INTRODUCTION.

CAUSES WHICH HAVE RETARDED THE ATTAINMENT OF SOUND PRINCIPLES IN PHYSIOLOGY.

An inquiry into the nature and extent of those causes which impede or arrest the progress of science, must be a subject of interesting speculation, not only to the philosopher, but to every one who is engaged in the pursuit, or interested in the advancement of useful knowledge. Such an inquiry, if skilfully conducted, by detecting the fallacy of assumed principles, and exposing the errors of popular systems, would diminish that undue veneration for antiquity, and that servile reverence of great names, which have so frequently prevented the discovery of truth; and by thus liberating the mind from the restrictive bonds of prejudice, would leave it free and unincumbered to pursue its onward course, in the paths of scientific research. It is only when the fetters of authority and system have been cast off by a powerful and superior understanding, that any great advances have been made in the spacious fields of science, in which, instead of exploring new tracts, the philosophers of our age have generally been content with walking servilely in the footsteps of their predecessors, or, if they have dared to depart from them, it has too often been under the misguiding influence of some imaginary notion, rather than the sure direction of those sound principles which were likely to lead to any valuable discoveries. To this cause we must attribute the slow progress of physiological investigation. On no other principle can we account for the extraordinary fact, that so many centuries elapsed before any knowledge had been acquired of the circulation of the blood, the connexion between the powers of the mind, and the development of the brain, the exact states of the body which promote or retard the generation of animal heat, and the true mode in which the fœtus is nourished. These secrets might have been made known, long before the period of their actual discovery, by any man of ordinary capacity; if, instead of being misled by prevailing opinions he had carefully examined the phenomena which nature presented to his view. Any thing intensely bright is seen more distinctly by the eye through a coloured medium, but the objects of mental contemplation are apt to be distorted, and rendered obscure, when viewed through any other medium than that of plain and simple facts, actually ascertained to exist, by careful and repeated experiments. He who recollects this truth will not be surprised at the slow progress of the science of medicine.

The ancients, though possessing much less general knowledge than ourselves, and not having nearly so accurate an acquaintance with the human frame, were almost as successful in the treatment of most diseases; since their superficial knowledge of the constitution of the body, and their entire ignorance of many of its organs and operations, reduced them to the salutary necessity of close observation, and a strict adherence to those means of cure which experience had discovered: but, amongst the moderns, speculation too frequently occupies the place of experiment, facts are disregarded in an eagerness to establish some favourite hypothesis; and the instructive voice of sage experience is not heard amidst the loud exclamations of noisy partizans, contending for the truth of new theories, and ever varying doctrines. The ancients were generally more practical, the moderns are more theoretical;* the former may, therefore, be sometimes safely followed, the latter seldom: but it would be dangerous to rely implicitly on either; the ideas of the one being often crude and ridiculous, those of the other visionary or imperfect. It has been justly asked, with reference to the present backward state of medical science: "What has medicine yet effected in increasing the bodily powers of man, in remedying his diseases, or in lengthening life, which can bear a moment's comparison with the prodigies effected by education, in invigorating his intellectual capacities; in forming his moral habits; in developing his sensitive principles; and in unlocking all the hidden sources of internal enjoyment?"*

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* But the primitive inquirers after truth, with greater fidelity and a happier conduct, used to throw all the knowledge they determined to collect and treasure up for use into aphorisms or short sentiments, not ranged into method, without professing or pretending to set down the whole of an art. — But as the case now stands, it is no wonder if men make no further progress in those things, which are delivered as if already perfect.—Nov. Org. sec. v. Aph. 86.

Education has certainly done much more to strengthen and improve the mind than medicine to invigorate and relieve the body; but the period is not very remote when the benefits which both might have sooner conferred—though the salutary influence of the former will probably, from the nature of things, be always greater than that of the latter—were lessened and retarded by the same causes. We read with astonishment, in the nineteenth century, that it was formerly considered a crime deserving severe punishment, either to doubt the correctness of the philosophy of Aristotle, or to call in question the medical dogmas of Galen. Since that period, however, of intellectual darkness and mental thraldom, moral philosophy has widely extended its dominions and brought to light many important truths, in consequence of its professors having, in a wise disregard of opinions and systems, however consecrated by age or revered by mankind, fearlessly pursued their researches into the *arcana* of nature with a spirit of patient, sober, and severe investigation, determined to be influenced in their decisions, only by reason and fact. Medicine, on the contrary, has made but little progress, because those who have devoted themselves to the study of it have, unfortunately, not followed the same scrupulous method of inquiry, nor examined with the same impartial scrutiny the nature of existing doctrines. They have either wholly received or rejected them after too superficial a consideration.

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* Philosophical Essays, by DUGALD STEWART, Esq., F.R.S.E. Chap. II., Preliminary Dissertation.

Medical science is frequently as much injured by sweeping away indiscriminately what is supposed to be false, as by adopting, without mature deliberation, what is conceived to be true. In this hasty mode of proceeding, many valuable suggestions are overlooked, and many erroneous notions are embraced. The fanciful reveries of DARWIN, relating to the principles of medicine; the ingenious doctrines of BROWNE, respecting the excitability of the system; the diversified views of BROUSSAIS and CLUTTERBUCK, on the subject of fever; and the various hypothetical opinions of others, concerning the nature and treatment of nervous diseases, from the refined speculations of LOBSTEIN, to the more simple and practical ideas of ABERNETHY, are either nearly or remotely connected with highly important truths, which, however, are not yet sufficiently developed, or clearly understood.

Though, amongst the numerous writers on medical and physiological subjects, many have frequently been misled by false theories, or too prejudiced an attachment to favourite systems, and none, perhaps, have avoided falling into considerable errors, much useful information, and many excellent observations are contained in their works: for, whilst the experience of one has furnished valuable facts, the imagination of another has occasionally thrown out brilliant and happy thoughts, which, if duly considered, may eventually lead to the detection of gross absurdities, and the establishment of sound principles. The science of medicine has, however, been retarded in its advancement *by the multiplicity of its expounders.* It is more easy to write on this science than almost on any other, and the inducements to attempt it are greater. To compose a work even of a very humble kind on natural or moral philosophy, requires superior intellectual powers, strengthened by much previous study, and long exercised in abstract speculations, or experimental pursuits, whilst such a work, even when creditably executed, does not bring its author either much reputation or profit: but the medical practitioner, with a very ordinary understanding, few acquirements, and but little mental application, may easily compile a treatise on some branch of his profession, availing himself of the labours of his predecessors, and drawing his matter from the existing stores of medical knowledge, which it is only necessary that he should arrange in a new form, and slightly modify, to secure both considerable fame and emolument.

The mere circumstance of being the author of a publication abounding in observations, appearing to be the suggestions of much skill and great experience, will give him additional importance in the estimation of the public, and, leading many to place implicit confidence in him, as an able physician, will greatly extend his practice. With so powerful a motive to publish, it is natural that medical practitioners, even of moderate abilities, should be desirous to appear before the world as authors, whilst the man of more enlarged and speculative mind will be further induced to make his views public by the pleasing consciousness of their originality, and a flattering conviction of their value. These views being supported by a long list of cases, and rendered plausible by arguments founded upon them, will probably meet, at first, with a favourable reception: as the reputation and influence of the writer increase, they will become gradually popular, and, being eventually adopted by the profession, almost exclusively regulate the general practice, till, the attraction of novelty ceasing, and some new doctrine coming into notice, they at length fall into neglect. Thus system succeeds system in quick succession; whilst, as one is exploded another rises into repute, the uncertainty of the medical science is supposed, by superficial observers, to be greatly diminished—a supposition, however, which, sooner or later, is proved to be erroneous, by the subsequent detection of fallacies, in what was too hastily concluded to be true.

In investigating the operations of nature, the inquiring mind is perplexed by studying them through the medium of these ever varying systems, which involve the most important subjects of medical and physiological inquiry in almost impenetrable obscurity. There are scarcely any truths in medicine, like the axioms in geometry, or the first principles in philosophy, so universally allowed, and fully established, that the student of this science can rely on their correctness; it is, therefore, absolutely requisite, amidst so many discrepant theories, clashing opinions, and opposite conclusions, drawn from the same experiments, to put every thing to the test of the most elaborate and tedious examination. Another cause, which has retarded the progress of medical knowledge, is *an almost exclusive attention to experiments.*

However valuable the important discoveries which have been made by a recurrence to experiments, much error has arisen from the false inferences that have been frequently drawn from them,—inferences which, though really the mistakes of erroneous observation, have been regarded as incontrovertibly correct.

It is very allowable to doubt the truth of propositions supported by argument alone, but it seems an act of bold temerity to call in question facts, or obvious deductions from them, said to be proved by direct experiment; and hence, whilst the former are fearlessly controverted, the latter are generally received with too easy an assent.

The physiologist, in his researches into the secrets of the animal frame, often forms very erroneous conclusions, in consequence of that narrowness of observation, which is contracted from a long and exclusive attention to experiments. The human body is a complex machine, consisting of different parts, so intimately connected together, and all so essential to its well-being, that no inference can be safely drawn from a separate examination of one of them, without maturely considering the exact relation which it bears to the rest.

In endeavouring, therefore, to ascertain the real office of any organ, it should be recollected that, though it possesses individual properties peculiar to itself, it has not an independent existence, but is connected by nerves and blood vessels with other organs, and is more or less affected, according to its nature and susceptibility, by every cause that produces bodily excitation or derangement. Expertness of hand, and an accurate acquaintance with anatomy, though very valuable acquisitions, are yet of less use to the experimental physiologist than a philosophical enlargement of mind, united to a well-grounded knowledge of the different branches of physical science. To one possessed of these requisite qualities, a single experiment, by leading to the discovery of some general law of the system, may furnish matter for the basis of an original and important theory, whilst it will suggest no new ideas to another, of more contracted mind, and less information, whose whole life is, perhaps, spent in the business of mutilation and destruction, without his discovering one useful or practical truth. Experimental physiology, like microscopical investigation, has a tendency to exercise the hand and the eye to the neglect and prejudice of the understanding. A habit of observation is indeed acquired, in the investigations connected with this pursuit; but it is observation of a very minute description, confined to the examination of particulars unconnected by any common principle, rather than directed to the scientific arrangement of them under any general heads.

The pure theorist, though possessed of the most brilliant talent, is too bold a speculator to be implicitly trusted, and the pure experimentalist, who does not possess superior abilities, is scarcely more to be relied upon. The one misleads by his ardent spirit of generalization, the other by his confined attention to particulars; the observations of the latter, founded on these particulars, being often as incorrect as the speculations of the former. It is seldom that minuteness of observation, and the comprehensiveness of mind, which is capable of taking general and enlarged views, are united in the same individual: these opposite qualities were, however, combined to a surprising degree in the celebrated HALLER. Endowed by nature with extraordinary powers of mind, he had the good fortune to be placed in circumstances favourable to their cultivation and development; so that there was scarcely any department of science with which he was not intimately acquainted, and to the extension of which he did not greatly contribute. He did much for the improvement of the present age, but he would have done considerably more, if, in addition to the light he himself reflected on physiology, he had enjoyed the advantage of that which has since been shed upon it by others.

The genius of BICHAT was of a different kind

—more bold and imaginative, it was less solid and exact, and. therefore, better calculated to form systems, than to give them a permanent stability. In RICHERAND we have an admirable instance of a theoretical physiologist—an elegant fancy and a refined taste, confer a pleasing charm on all his productions, but they communicate scarcely any original or important information. The sober judgment and enlightened understanding of MAGENDIE, cannot be too much admired. In all his investigations he proceeds with great caution, and, instead of suffering his mind to be biassed by preconceived notions, he almost invariably appeals to nature as the safest guide and instructor. If there be one fault in this eminent physiologist, it consists in his too confined and exclusive attention to experiments, which sometimes prevents him from taking a sufficiently enlarged view of the animal economy, and from classifying the various facts with which he becomes acquainted, so as to render them practically useful: but his facts are generally correct and clear, resembling pure gems, unincumbered and unobscured by foreign matter. Had all the writers on physiology and medicine possessed the talents of this distinguished author, and industriously employed them in the study of the same sciences, they would have been more clearly understood and more fully developed. In their present imperfect state, they may be compared to vast oceans and extensive continents, with which we are but little acquainted; even their boundaries being undetermined, and their treasures almost entirely unknown: but the slow progress of these sciences, during many centuries, is not to be regarded as any proof that their principles are incapable of being more accurately defined, and their limits more widely extended. If the causes which have so long retarded their advancement can be pointed out, a reasonable expectation may be entertained, of their further improvement and more useful application to the purposes of life—to the amelioration of its sufferings, and the increase of its enjoyments : and if I am sanguine in my anticipations of what may be accomplished by the future labours of physiologists, my expectations arise from a clear perception of the errors which were formerly committed, and an intimate acquaintance with the great improvements which have been made in modern times. To augment these, physiologists must patiently refer every hypothesis to the test of experiment ; but, cultivating less mechanical habits of thought, they must, at the same time, exercise the mind, even more than the hand and the eye.

Errors, similar to those which I have previously described, as retarding the progress of physiology, are pointed out by the immortal Bacon, in the following admirable passage from his *Novum Organum,* in reference to the proper mode of studying the sciences :— "Those who have treated the sciences were either empirics or rationalists. The empirics, like ants, only lay up stores, and use them ; the rationalists, like spiders, spin webs out of themselves; but the bee takes a middle course, gathering her matter from the flowers of the field and garden, and digesting and preparing it by her native powers. In like manner, that is the true office and work of philosophy, which, not trusting too much to the faculties of the mind, does not lay up the matter afforded by natural history and mechanical experience, entire and unfashioned in the memory, but treasures it, after being first elaborated and digested, in the understanding; and, therefore, we have a good ground of hope, from the close and strict union of the experimental and rational faculties, which have not hitherto been united."*

It is gratifying to observe, that a spirit of inquiry seems to be spreading amongst the members of the medical profession, and that they now generally display so much information, that we may be assured they will every day become less satisfied with existing systems, and, examining every hypothesis, however ingenious and plausible, will reject what is merely fanciful and unsupported by fact. If a work, like the Zoonomia of DARWIN, were to be published in the present age, its reception would be very different from that of this once celebrated production, which, at the time of its first appearance, being universally commended and admired, was supposed to have conferred on its author an imperishable fame: but it has since gradually fallen into neglect, and is fast hastening to oblivion. The increasing light of science has exposed its great defects and glaring absurdities; and the Zoonomia now scarcely serves any other purpose than to indicate the progress which medical knowledge has made since the period of its publication. Abounding, as it does, in fanciful notions, assumed premises, and false conclusions, it seems wonderful that it should ever have obtained any degree of reputation; but the wonder ceases, when we consider the low state of the medical profession in the last century, to which, and not to any great excellence in itself, its former popularity is to be attributed. The *Study of Medicine,* by Mason Good, affords the clearest evidence of the advancement of this science in late years; but I am disposed to think, that the merits of this treatise have been much overrated. It cannot be denied that it displays considerable learning, and contains many important facts and useful observations; but the value of these is much lessened by their being very frequently blended with false doctrines and physiological errors. The work is, indeed, enriched with a vast fund of knowledge, brought from almost every quarter; but to render that knowledge really useful, it ought to be much more carefully examined and scientifically arranged.

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* Sect. VI., Aph. 95.

The author would have conferred a much greater benefit upon society, if his plan had been more limited, if it had been confined to some particular branch of medicine, instead of embracing the whole of the sciences, the departments of which are too numerous in their present imperfect state, and too full of errors to be comprehended by one mind, or to admit of generalization. No system of medicine can indeed, be formed with advantage, till its principles are more thoroughly understood, and firmly established; in the meantime, the best method of leading to a more perfect acquaintance with them, is for individuals to apply themselves to the study of those particular branches of the profession which circumstances afford them an opportunity, or nature gives them an inclination to investigate. The indefatigable industry and extensive knowledge of MASON GOOD fitted him for the task of compilation, and his *Study of Medicine* is certainly an elegant and learned production: but his numerous and diversified acquirements were not calculated to render him practically useful as a physician, or eminently serviceable as a writer on medical subjects. The mind is, indeed, enriched by abundant stores of information, but the judgment is not proportionally strengthened; and the time spent in the acquisition of varied and extensive learning, must necessarily be taken from that which ought to be wholly devoted by the medical practitioner to the exclusive studies of his profession. A general knowledge of many subjects, being almost necessarily received without due examination, is seldom exact, or correct; this is particularly true of medical knowledge which does not admit of accurate calculation, and the correctness of which can be ascertained only by the long and tedious process of individual observation, accompanied by a spirit of candid and patient enquiry, unbiassed by prejudice, and seeking only for truth.

In these introductory remarks, I have fully attended to those causes which appear to me to have principally retarded the advancement of the science of medicine, and in the following pages, with equal freedom, I have attempted to refute what I conceive to be the erroneous opinions of preceding writers, on a very important and difficult subject of physiological investigation. I am well aware that with those, who are strongly attached to popular systems and prevailing notions, the freedom of my observations will, probably expose me to the charge of bold presumption : but the candid and intelligent reader will, I trust, acquit me of such presumption, when he considers that the most pernicious errors can be removed only by a fearless refutation, and that it is the duty of every member of the medical profession to expose whatever is connected with it, that, in his estimation, is either false in theory, or injurious in practice. I claim, however, no infallibility : and, if in attempting to correct the mistaken opinions of my predecessors, I should myself have embraced others equally erroneous, I shall not only be most thankful to any one, who will candidly point them out, but be the first to reject them on a sufficient proof of their fallacy.

THE

PHYSIOLOGY

OF THE

LIVER AND SPLEEN.

THE present subject is one which has always been considered difficult, and the researches of the most distinguished anatomists and physiologists have not hitherto removed the mystery in which it is enveloped. Most of the opinions advanced by the ancients are hypothetical, and those which have been brought forward in modern times, aided by a more intimate knowledge of the animal economy, are either of this character, or too contracted, in theory or experiments, to be regarded as complete and satisfactory.

I shall not trouble the reader with an enumeration of the different opinions which have been advanced concerning the office of the spleen; for, as I do not propose to attempt a refutation of them individually, it is not necessary to state them. Two of the best books upon the subject, with which I am acquainted, are Dr. STUKELY'S, published in 1723, and one by MORESCHI, Professor of Comparative Anatomy in Pavia, in 1803. The doctrine inculcated in both is, *that the spleen is an organ appropriated to the digestive function, supplying blood according to its demands.* When the capacity of the stomach is enlarged by the food which is received, it is supposed to press upon the body of the spleen, so as to diminish the accumulation of blood in the splenic artery, and thereby to augment the action of those vessels which are distributed upon the stomach. This view, with slight and immaterial modifications, is the one proposed by both authors. The necessity of a vigorous circulation during the process of digestion can scarcely be called in question. This state of the sanguiferous system is to be regarded as indispensable, and the views which support it are much more consistent than the ideas at present entertained with respect to the efficiency of the nervous system. The numerous and well-conducted experiments of WILSON PHILIP seem to shew, that the nerves are the principal instruments in promoting the assimilative changes; but these experiments are not to be considered by any means as demonstrative of the fact. *They shew that digestion ceases when the eighth pair of nerves, is divided; but, as circulation and respiration are extensively influenced by this operation, it cannot be doubted, that this physiologist has remarked the functional disorder produced, and has ascribed it, without due consideration, to the immediate loss of nervous energy belonging to the stomach.*

That the principles, which this physiologist has deduced from his experiments, are fallacious, is not difficult to prove. In a work, which I lately published, it was satisfactorily shewn, that the division of the eighth pair of nerves is injurious to the digestive powers of the stomach, *in proportion only to the disorder induced in those of respiration and circulation.*[*] When these were protected by the introduction of a small tube into the divided trachea, which enabled the animal to breathe with facility, digestion proceeded as *correctly, although a portion of the nerve on each side was excised,* as when the nerves were left entire; the trachea alone being separated, and a tube attached, as in the preceding instance.

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[*] See an Experimental Enquiry into the Laws which regulate the Phenomena of Organic and Animal Life.

The authors first referred to having endeavoured to shew that the spleen performs this vital office to the stomach, find a difficulty in explaining how the stomach acts when deprived of this auxiliary; in fine, the difficulty appears so great, that MORESCHI gives little credence to the possibility of such an occurrence in the human frame, and observes that this taking place in the inferior animals cannot be considered as any objection to the action of the spleen in the human subject.*

If authorities were required to prove, that the human spleen has sometimes been excised, it would be easy to bring forward instances. Several cases are on record, where part of the organ was excised, and the remainder was returned without injury to the individual; and it is mentioned by authors of credit, that accidents have occasionally happened, in which the spleen has protruded and has been removed with safety, the vessels having been previously secured by ligatures.* It has also been stated, that in one or two remarkable cases, no spleen whatever was found; and, in many persons, it has been observed so diminutive, as to preclude the idea of its exercising that function with which physiologists have endowed it.

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* "Per quanto poi concerne la nostra specie, sono intimamente persuaso, che quanto è stato scritto intorno all' amputazione ed all' induzione della milza possa tutto rapportarsi ad una semplice millanteria; non potendo essa praticarsi senza offendere notabilmente il peritoneo, l'omento, parti che sebbene sembrano poco fornite di sangue, pure sono estremamente vascolari, facili ad infiammarsi, e tirar in consenso anche gli altri organi del basso ventre, cui somministrano l' estrema membrana, per non parlar anche di tutti quegli altri disordini, che provenir potrebbono nel travaglio della digestione dalla tolta armonia, e reciproca cospirazione della milza collo stomacho."—Del vero e primario uso della milza nell' uomo, &c., di MORESCHI, p. 84.

Sir EVERARD HOME has made many experiments to ascertain the function of the spleen. In his first paper on this subject to the Philosophical Society, he was inclined to believe that this organ was the medium of communication between the cardiac portion of the stomach and the circulation of the blood. When the pylorus was secured by ligature, and an infusion of rhubarb was injected into the stomach, he found, if the animal were killed a few hours after, that a quantity of the fluid had escaped. This fact was readily ascertained by measuring the proportion which had been rejected by vomiting, and what remained in the stomach. The presence of rhubarb was detected, by chemical tests, in the spleen, the splenic vein, and the urine, and, in some of his experiments, in the liver. In another paper, which he subsequently read to the Philosophical Society, he gives a series of experiments, which refute the opinion he had formed with respect to the use of the spleen. In these experiments the spleen was excised, and yet the urine was found strongly impregnated with rhubarb, the infusion of which had been employed. Unable to discover the function of this organ in the animal economy, he thus concludes his communication, " that the fluid contained in the cells of the spleen is secreted there, is rendered highly probable, since it is most abundant while the digestive organs are employed, and scarcely at all met with when the animal has been some time without food. The great objection to this opinion is, there being no excretory duct but the lymphatic vessels of the spleen; these, however, are both larger and more numerous than in any other organ; they are found in the ass to form one common trunk, which opens into a large gland on the side of the thoracic duct, just above the receptaculum chyli; and when the quicksilver is made to pass through the branches of this gland, there is a trunk equally large on the opposite side, which makes an angle, and then terminates in the thoracic duct. These lymphatic vessels are equally large as the excretory ducts of any other glands, and therefore sufficient to carry off the secretion formed in the cells of the spleen; and where a secretion is to be carried into the thoracic duct, it would be a deviation from the general plan of the animal economy, were any but lymphatic vessels employed for that purpose."*

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* Works of BAILLIE, by WARDROP, Vol. II., p. 235.

There is one objection to the importance which Sir E. HOME appears to attach to the secretory powers of the spleen, which is not very easily removed. If the secretion be of vital consequence to the system, how does it happen, that the excision of this organ in dogs and other animals is not attended with serious effects? To endow an organ with an indispensable office, while we find, when it is destroyed, that the animal and organic functions of the body are carried on with regularity and perfection, does not appear very philosophical. The function which I have ascribed to the spleen is not liable to such objections.

MALPIGHI frequently removed the spleen of dogs, without observing any material effect;

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* Phil. Trans., Part II., 1811.

and M. Assollant has lately performed the operation on 46 animals of the same kind, under the direction of Baron Dupuytren, with the same results. The following passage shows, that the operation may be performed without disturbing the vital functions of the system :—"Dans toutes les expériences faites par M. Assollant sous les yeux de M. le Professeur Dupuytren, on n'a remarqué aucune changement dans la couleur et la texture des parties de ces animaux ; *chez eux la digestion, l'absorption, la circulation, la respiration et la voix, les secretions, la nutrition, la locomotion, la sensibilité, les sensations, les facultés instinctives, la reproduction, aucune de ces functions n'a prouvé le moindre trouble.*"*

The spleen has also been removed by Dr. Saunders, for the purpose of ascertaining whether it contributes in any way towards the secretion of bile. "It is imagined by some," he observes, "that the blood, in its course through the spleen, receives changes, which enable it the better to concur with the liver in the secretion of bile. Baron Haller was of opinion, that the blood, returned by the epiploic and mesenteric veins, contained a large portion of the adipose matter, which it received by the absorbent power of those veins, and which imparted to it a great degree of viscidity, that without the diluting power of the splenic blood, which mixes with it when entering the *vena portarum*, it would be liable to concrete." These and a variety of other hypotheses are disproved by direct experiments instituted by Dr. SAUNDERS. "The result of these experiments," he says, "makes it highly probable, that the bile secreted after the loss of the spleen, differs in no respect from other bile; and that the liver, in the exercise of its functions, is perfectly independent on that viscus."*

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* Dictionaire des Sciences Medicales, Jour. XLVII. p. 246.

Without multiplying proofs, it is evident that the spleen is not necessary for the function which has been ascribed to it; for if it were indispensable to the perfect digestion of food, this process would be impeded or destroyed, whenever the stomach was deprived of its assistance, which however is not the case. But although we have not hitherto been successful in discovering the nature of its office, we are not to conclude, that it occupies its present situation merely for the purpose of filling up a vacant space.

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* A Treatise on the Structure, Economy, and Diseases of the Liver, by WILLIAM SAUNDERS, M. D., F. R. S., & S. A.

The physiology of the liver is almost as little understood as that of the spleen. Much has been written on the function which it is supposed to perform, viz. the secretion of bile; but it is still undecided whether this be effected by means of venous or arterial blood. If by the latter, for what end is so much venous blood directed to the liver? and, if by the former, the difficulty still remains in accounting for the great quantity of oxygenated fluid which is transmitted to it.

In whatever manner the subject is viewed, according to the established notions of the day, the physiology of the liver is involved in obscurity. BICHAT, after enumerating the various uses of the liver, observes, "De toutes ces considérations et de beaucoup d'autres que je pourrais ajouter, on peut conclure, je crois, que le rôle inconnu que le foie joue dans l'économie animale, outre la sécrétion bilieuse, *est des plus importans. L'étude de ce rôle est un des points les plus dignes de fixer l'attention des physiologistes.*"*

DR. SAUNDERS states unequivocally, that

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* Anatomie Générale, vol. I. p. 405.

bile is secreted from venous blood. "While other fluids," he says, "are secreted from florid arterial blood, which has lately received changes from the air by the intervention of the lungs, the bile is formed from blood of a dark colour, possessing the common characters of venous blood, and is conveyed to the liver by a vein. That venous blood is more favourable to this secretion than arterial, is very evident; and this exception of the liver to nature's law in the economy of other glands, may be admitted as a proof of it." In another part of his book he remarks: "It has been proved above, that venous blood is the proper source of the biliary secretion."* This intelligent physician has not adduced any facts in support of this opinion, nor is his reasoning of so convincing a character, as to authorize such decided assertions. He allows that nutrition is invariably accomplished at the expense of arterial blood; and still further, that all secretions of the system, except that of bile, are derived from this fluid. The colour, consistence, and qualities of the bile, are no indications whatever that it is the production of venous blood: this secretion does not differ more widely from other secretions, than these do from one another. What analogy is there between the properties of semen and those of tears? Though he allows that all secretions previously existed in the blood, yet he considers that the striking varieties observed are to be ascribed to the peculiar structure of the secreting organ. According to his own principles of reasoning, he cannot deny to the liver the faculty of secreting bile from arterial blood.

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* Vide pages 19, 36, and 50. Opus supra cit.

Dr. BOSTOCK imagines "When the venous blood becomes loaded with inflammable matter, which cannot be discharged from the lungs, principally in consequence of the high temperature to which the animal is exposed; and when, from certain causes, one of which appears to be the increase of cutaneous perspiration, this excess of inflammable matter is not employed in the deposition of fat, the liver would appear to be the organ by which it is removed."

"The considerable magnitude of the liver," observes CUVIER, "in those animals which respire least, and its total absence in insects, which possess the most complete kind of respiration, since their whole body forms, as it were their lungs, have induced us to conclude, that the liver in a certain degree supplies the place of the lungs, and like them, serves to remove from the blood its two combustible principles."* A similar idea is entertained by CARUS. "The function of the liver," he says, "as a secreting organ, differs from the secretory action of the lungs in this respect, that the latter expels carbonaceous matter in a gaseous state, and the former a similar matter in a more solid form."†

The opinion of Dr. BOSTOCK is founded on the gratuitous assumption, that bile is secreted by venous, and not by arterial blood. If we examine other organs, we perceive that the *activity and extent of their functions are proportionate to the quantity of arterial blood which they receive*; nor is it possible to discover one organ which is in the least directly indebted to the venous system for the performance of its office. In the severe forms of asthenic affections, when the arterial blood is evidently deficient in its usual oxygenated properties, every function, whether recrementitious or excrementitious, exhibits a corresponding debility or aberration; and still further, a case is on record which shews an unusual distribution of the vena porta, this terminating in the vena cava inferior without its contents having previously circulated through the liver.* Such a fact as this is more valuable towards the elucidation of the subject than all the ingenious theories we possess.

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* Lectures on Comparative Anatomy, Vol. I., p. 57, Trans.

† An introduction to the Comparative Anatomy of Animals, by C. G. Carus. Trans. from the German by R. T. Gore.

In this case of *lusus naturæ* the secretion of bile seemed to be as regular and perfect as in those individuals whose organization is natural.

The opinion that bile is formed from venous blood seemed to receive considerable support from the investigations of Dr. JACOBSON, of Copenhagen, into the distribution of the venous system in birds, reptiles, and fishes. He states *three general modifications* of the system belonging to them, which are succinctly expressed in the following words:—"The blood returning from the middle and posterior part of the body in the *first* and *second* modification of this system, is conveyed only to the kidneys; but in the *third*, to the kidneys and liver."†

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* Phil. Trans. for 1793, Part I.

† Edinburgh Medical Journal, Vol. XIX., p. 79.

These facts, instead of removing the difficulty connected with the secretion of bile, increase it. That the secretion of urine is derived from arterial blood in the extensive class of mammalia, has never been doubted; and, therefore, it is as much an assumption to advance that this fluid is derived from venous blood in the kidneys, as it is to assert that bile is formed from it in the liver. Now, if the former assumption were true, in what manner should we account for the circulation of a considerable quantity of arterial blood in the liver? Is not the proportion much greater than what would appear necessary to maintain its individual vitality?

Supposing the kidneys of birds, reptiles, and fishes, have the same relation to the venous system as the liver of mammalia, we have still to be informed whether the *quantity of urine secreted bears an exact proportion to the venous, or to the arterial blood which they receive.* If to the former, there is more harmony in the relation of cause and effect in the kidneys than is found to exist in the liver, and those who support this view have still to discover the use of the arterial blood. " A liver exists in all the *mollusca,* and is very large; but this class has no gall bladder. The liver is supplied with blood from the aorta, and there is consequently no *vena portarum*."* Here we observe a secreting organ, whose function is exclusively performed by arterial blood, a fact which strengthens the opinion, that the secretion of bile is the product of arterial, and not of venous blood.

The properties of arterial blood, and its obvious utility, are fully stated in the experimental inquiry to which I have previously alluded, and from the facts and reasoning connected with the investigation, I am disposed to infer that all secretions are to be ascribed to the qualities of arterial blood, and, consequently, that bile is derived from this fluid; though I do not imagine that the liver performs no other function than the secretion of bile.

We are acquainted with certain organs of the body whose functions can scarcely be mistaken, being adapted either to propel or to oxyginate the blood, to give motion or sensibility, or to promote evident secretions. This knowledge enters more or less into every idea of the nature of other functions which is not satisfactorily ascertained. If we observe a large organ, we almost immediately attribute to it one of the above offices. This mode of estimating the intentions of nature is contracted and unphilosophical, and as long as we pursue this course of reasoning, so long will many of the most important operations of the system be enveloped in mystery. *The body is made up of a variety of organs, possessing different degrees of importance, according as they contribute either to the pleasure, the health, or the existence of the individual.* The lungs and the heart are the most important, if not the only vital organs of the system ; and from the views according to which I propose to explain the functions of the liver and spleen, it will appear, that nature has been particularly solicitous to protect them. The means which she has employed to guard the eye, the ear, and the contents of the chest are apparent ; and are those parts which are constituted for this purpose *to be regarded as performing no functions?* If in these we perceive wisdom of design, how much more apparent will it be from an examination of the various provisions which have been made in order to secure the life and health of animated beings!

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* Blumenbach's Manual of Comparative Anatomy. Trans. Lawrence, p. 129.

From what has been previously explained, it is evident that the hepatic artery is regarded as the source of bile; and believing the production of this to be only one function of the liver, it is my intention to account for the great quantity of venous blood transmitted to it and the spleen. Both organs are well adapted to receive a great share of sanguineous fluid, whether we consider the texture as composed of blood vessels or of cells.

The function of the spleen, as well as that of the liver, independently of the secretion of bile, is considered a *diverticulum* of the system. *If the veins which form the vena porta had passed directly to the vena cava inferior, a thousand accidents, arising either from mental or corporeal disturbance, would have continually placed the life of an individual in imminent danger. Every passion, whether of an exciting or depressing character, and every general and local disease, if severe, whether chronic or acute, would have been liable to have deranged the lungs and heart.* I have already endeavoured to shew, that passions, of a depressing nature, bring the blood in greater quantity than usual from the inferior and superior extremities, and also from the surface of the body to the chest; and I have also stated, that the abdominal viscera participate in this engorgement.* Since the body is continually liable to such changes, baneful effects would follow, unless nature had provided organs, whose situation, function, and organization, enable them to *diminish the burden imposed upon those, whose constant and almost regular action is indispensable for the maintenance of life.* This object is beautifully answered by the liver and spleen. The organs within the chest must be regarded as possessing vital functions. If the lungs were surcharged with blood, or in a condition approaching to it, the properties and distribution of this fluid would be immediately disordered, and with this primary derangement every part of the body would quickly sympathize.

The liver and the spleen, from being placed close to the thorax, are calculated to relieve the congested lungs and heart, or rather to protect them from sudden and violent commotions; and are also favourably situated to protect in the same manner the stomach, whose action is scarcely less vital.

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* See Experimental Enquiry, Chap xv.

If we investigate the manner in which venous blood circulates in the liver, we shall be convinced that its minute divisions, on this principle, are well calculated to facilitate the object that nature has in view. The vein ramifies through every part of the organ, in the way in which arteries divide themselves: if it had not been thus distributed, the liver would not have contained a quantity of blood equal to what it does at present; nor would it have been retarded, as it is, by the nature of its circulation, in its flow to the lungs, which appears an indispensable provision in order to protect these organs.

The spleen is, by some, supposed to be formed of vessels; by others, to be chiefly composed of cells; but, whichever opinion we adopt, it is manifest, that its structure is particularly well formed to allow of considerable congestion or enlargement. In those instances, in which the circulation is very much disordered, and in which we have determination of blood to the internal organs, the liver and the spleen are occasionally so much augmented in size, that they cannot be supposed to contain less than many pounds of blood. If these organs had been absent, or incapable, from structure or situation, of receiving an extra proportion, this quantity would have been added to that which is already retarding the action of more vital organs, the consequence of which would be *the total cessation of life.* We may complain of the enlargement or disorganization of the liver and spleen, but we must remember, that although we occasionally suffer from the diseased conditions of these organs, we are preserved from many acute affections, which would seldom allow man to to arrive at maturity, unless the constitution were endowed with instruments fitted to bear oppression. If we consider the temperaments most subject to derangements of these parts, the diseases which affect very much the internal viscera, and the influence of external agents upon the body, we shall probably observe more clearly the consistency of the view proposed to explain the functions of these organs.

Of all the temperaments, the melancholic is by far the most frequently characterized by disease or augmentation of the liver and spleen. Indeed, so common is it to find these conjoined, that it has been imagined that there exists a necessary connexion between them.

The greater part of the ancients supposed, that these organs were the seats or causes of this temperament, and although it is impossible to grant that any viscus or viscera of the abdomen can fashion the peculiar constitution of the mind, still the universal language of mankind proves, *that these organs were generally large or diseased in individuals of this temperament.* We very rarely find persons so constituted take constant exercise; their habits for the most part are sedentary, and instead of enjoying the gaiety and hilarity of convivial parties, they generally prefer solitude, or are occupied in brooding over real or imaginary evils. In the chapter on the Physiology of the Passions, already alluded to, the manner in which the body suffers from a disorder in the powers of the mind is fully discussed; and as the feelings of melancholy are considered to operate in the same way, as those which were referred to the division of mental sedatives, there is little further to add on the present occasion.*

A life of inactivity, or one abounding in disagreeable sensations, *tends to determine the blood*

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* See Experimental Enquiry, Chap. xv.

internally, and those organs which are best adapted to bear this determination, or state of congestion, will suffer to the greatest extent. The liver and spleen being formed in every respect, to receive the principal share, they will necessarily exhibit symptoms of derangement or disease, as if they were the only disordered organs, but in this state of the system we also remark, very frequently, if not constantly, acute headache, palpitation of the heart, sometimes cough and difficulty of breathing, or aberration of the mental faculties; and unless the two abdominal viscera had been so constituted and placed, the whole train of the latter effects would have become too prominent for the existence of the animal economy. If these principles are allowed to be correct, the treatment of nervous diseases must be considerably modified.

From the variety and importance of the abdominal organs, diseases are frequently occurring in them. Congestions, or inflammations, either remaining local, or exciting general fever, or producing their ordinary consequences, such as adhesions, disorganizations, dropsies and tumours, disturb the regular course of the circulation, and very much disorder the functions of the heart and lungs. But how much more would these organs be oppressed, if the liver and spleen had been incapacitated, either from structure or functions, for performing the office for which nature is supposed to have intended them! If each had any other exclusive part assigned it, to secrete, for example, to assimilate, to propel, or to endue with sensibility, or motion, it would be impossible to conceive, that any one of these functions could remain amidst such constant disorder, or disease; and if this argument be allowed, it is clear *that the more vital or necessary organs of the system could not withstand the oppression arising from the determination or congestion of blood.*

Intermittent fevers, and particularly those of the quartan type, are of all agents the most powerful in disturbing the abdominal organs. In these the liver and spleen are occasionally observed of immense size, occupying the two hypochondriac regions, and extending over a considerable portion of the abdomen towards the hypogastrium. It would seem that these large organs were the seats of the disease, but as they have little influence in causing or exciting a predisposition to it, we must look to other sources for its origin; and if we reflect for a moment on the quantity of blood accumulated in these two viscera, we shall be almost under the necessity of acknowledging, that if this had been distributed equally among the heart, the lungs, the brain, and the abdomen, the powers of life would have been destroyed.

The various organs enumerated are not deprived of their usual share of the sanguineous fluid, during the congested condition of the abdominal organs, *but actually possess more, and therefore a farther increase would be fatal to their action.* This condition of the two organs in question, has so frequently presented itself to the pathologist, as to lead him to suppose, that the seat or cause of fever is not unusually resident in one of them; and although I am willing to grant that this may occasionally be the case; yet, I am firmly persuaded, that *post mortem* examinations have too often induced him to regard effects in the light of causes. In fatal cases of fever, whether of an intermittent or typhoid nature, how often do we observe these organs enlarged; of a firm but brittle texture, according to the extent and continuance of the disorder; and, at the same time, the mucous membrane of the stomach and intestines, exhibiting a vascular appearance, or here and there patches in various degrees of congestion or inflammation; and while we remark these simultaneous consequences, we are astonished to find the ventricles of the brain well charged with serum, or its vessels and membranes as much diseased as the preceding organs. Such cases furnish a striking proof of the inefficiency of nature in struggles of this kind; although she is prepared to contend, for a time, from possessing organs every way calculated to ward off the momentary attacks of disease; yet, when these are violent, or long-continued, the auxiliary means are overcome, and it is then, that the vital functions of the system are oppressed or destroyed.

The above description of the results of fever shews, with what facility and plausibility the speculative physician may argue concerning its seat or origin. How natural it is for a CLUTTERBUCK to take possession of the head; how consistent for a BROUSSAIS to seize upon the stomach and intestines; and how reasonable for the whole world to turn their attention to the liver and the spleen, as the sources of febrile action. While we admire the genius and acquirements of these systemfounders, it is certainly to be regretted, that their theories ever formed principles of practice. Although they themselves may have minds too expanded to be confined within the trammels of their own systems; yet their followers, unfortunately, either from ignorance or respect, slavishly follow them.

In speaking of the influence of passion, I alluded to several cases of jaundice, mentioned by BICHAT and GEORGET, as the consequence of depressing feelings of the mind; and such a phenomenon, according to the explanation given, *shows the origin of the symptom, and the liability of the liver to congestion.* This is an occurrence by no means rare; but the frequency and severity of this condition, arising from mental emotions, demonstrate the necessity of such an organ. If it were absent under such circumstances, the lungs would immediately be surcharged with blood; if they were able, for a short period, to continue their operations, these would be so feebly and imperfectly performed, that death would speedily take place, either in the heart or the brain. Is it possible, then, to suppose that the liver and spleen have no functions, when they conjointly contribute to preserve the constitution from almost instantaneous destruction, or acute diseases, whenever the equilibrium of the circulation is deranged!

It may, probably, be advanced, in opposition to the present view, that individuals frequently die from disease of these organs, and, therefore, they may be considered injurious, as a disordered action would not be present to derange the animal economy, if these viscera had formed no part of the system; or, if the liver be supposed so small as simply sufficient to secrete bile, this state of diminution is almost equivalent to its absence, in regard to its office as a *diverticulum.*

In every instance, except in those in which these organs suffer from external injury, it cannot be called in question, that the acute or chronic affections of these parts, are invariably to be attributed to general or local disorders, that would have soon destroyed life, unless certain viscera had been so constituted, as to divert the excited action, or overloaded state of the blood vessels. In the *severe* forms of inflammation of the mucous membrane of the bowels, the peritoneum, stomach, or kidneys, death sometimes occurs, without any other organ, save the one affected, being particularly diseased; but this fact furnishes no objection whatever to the office assigned to the liver and spleen; for the local affection may have been so great, as to overwhelm the powers of the system, by the general disturbance induced by it, *in degree too violent to be lessened by the functions of the above organs, or in extent too great to be controlled by any capabilities they possess.* But though these cases seem opposed to the principles inculcated, if we turn to the various diseases of the abdomen, in which these organs occasionally participate, to a considerable extent, we shall find that the parts primarily implicated have their acute states transformed into chronic conditions, and that these are either rendered mild, or subsequently removed from the beneficial influence of the auxiliary organs.

In intermittent fevers, and in many other diseases, but particularly the former, the liver and spleen are found similarly affected; and from this circumstance, we should suppose, *that there was one office common to both, or one condition of the system which affected them equally; and we also observe, that the means which relieve one, benefit equally the other.*

Having now briefly considered the importance of the liver and spleen, as *diverticula* to preserve from disease, or to alleviate its severity, it is scarcely necessary to observe, that it is easy to explain the possibility of the spleen being excised in man, and in the inferior animals, without detriment to either, except from inflammation almost inseparable from the operation. If it be removed, and the individual recovers his wonted energies, these may exist for a series of years; because their exercise does not depend upon the spleen, but upon the proper action of organic laws, which are equally independent of the same organ in the undisturbed state of the system. *Its office is not to contribute, every moment, to the maintenance of life; but only, on trying occasions, to develope the full powers of its functions, and, in conjunction with those of the liver, to protect the vital principle from destruction.*

The liver and the spleen are not only valuable to the human species as *diverticula,* but they are also of essential service to every gradation of animal life, in which one or both are found. In these, perhaps, the organization of the system may be more simple, and its susceptibility of external impressions less acute, than in the structure of the human frame; but although there may be a difference of this kind, yet it is almost indispensably necessary, *wherever a vigorous circulation exists, that one or both organs should be present, in order to lessen the pernicious influence of external causes, which have a tendency to disturb the regular distribution of the blood.* In the preceding pages, it has been remarked, that these organs tend to protect, from sudden and extensive injury, the functions of the thoracic viscera, and the digestive powers of the stomach. The lower animals are frequently placed in circumstances, in which it is requisite to the well-being or preservation of their existence, that they should possess instruments capable of mitigating the injurious effects arising from a copious or instantaneous determination of blood to the internal organs. If an animal be chased for any length of time, or if it be strongly excited in the pursuit of its prey, the circulation of the blood is very much disordered; and when a state of rest succeeds this violent excitement, though the blood was before diffused in abundance over the surface of the body, it becomes accumulated in the same proportion in the internal organs. Great muscular exertion always gives rise to a diminished action of the heart; and if this be debilitated in consequence of previous excitement, it immediately produces an internal determination of the blood. This fluid is transmitted to the surface of the body in greater quantity than usual during exercise, from the increased contractions of the heart; and if these become fewer, or less energetic, it cannot possibly be maintained there in the same quantity, and will, therefore, become internal in its distribution; giving, till the circulation regain its natural action, an undue proportion to those organs which are best adapted to receive it. The liver and the spleen are certainly well calculated to bear great oppression, without directly endangering the powers of life. One or both of these organs are found in the mammalia, amphibia, and in birds and fishes. When both are found, their size is in inverse ratio to each other; but when only the former, it is generally large. From these circumstances, physiologists have been led to suppose, that the spleen contributes to the secretory functions of the liver, by converting arterial into venous blood; that is, by depriving the arterial fluid of its vital properties.

It has never been proved that bile is the production of venous blood; and analogy, together with the facts we possess in regard to the secretion of this fluid in certain classes of animals, as the mollusca, for example, in which there is no vena porta; and the few solitary cases of *lusus naturæ,* in which the liver has been supplied exclusively with arterial blood, are certainly opposed to such a conclusion. If the liver and the spleen be allowed to be *diverticula,* we observe the wisdom of Providence in making the former large in those animals which do not possess the latter, or in developing them in those which have both, in an inverse ratio to each other. The spleen, in the different classes of animals, is certainly well calculated, from its situation, to preserve the stomach, and the source of circulation, from being violently disturbed whenever sudden and extensive changes occur in the sanguiferous system. In the mammalia this organ is almost invariably found at the left side of the stomach, or, if there be several stomachs, it is placed at the left side of the first or larger one.* In birds, it is observed to be connected with the glandular cardiac cavity, and the left portion of the liver. In the amphibia, it is generally attached to the left side of the stomach, as in the salamander, or placed near the colon, as in frogs and toads, while in fishes, it is not unfrequently connected with the larger end of the stomach. If we investigate the various causes which are capable of influencing the circulation of the blood in these different classes of animals, we shall be fully convinced that the function, which I have ascribed to the liver and spleen, is of vital importance whenever these causes are in operation. The variations in the temperature of the atmosphere, from heat to cold, are calculated to disorder the circulatory system, particularly in warm-blooded animals. The feathered tribe are very generally affected by the severity of winter, although nature, at this season of the year, provides them with a plumage better fitted than the one they possess in the summer, to enable them to endure the bleak winds and long cold nights; yet thousands perish from their inability to withstand the inclemencies of the weather: whilst the appearance of those that survive is haggard; their cheerful songs are no longer heard, and their sufferings are indicated by their silence. But, after the genial excitation of a few warm days, they are continually flying about on buoyant wings, and, by their early notes, and sprightly motions, intimate the restoration of those vital energies which invariably return with the blooming flowers, and the genial rays of spring. If, however, the warmth and brightness of these sunny days are chilled and overcast by a return of frosty and tempestuous weather, both the animal and vegetable kingdoms again droop. Plants have vessels, through which sap, in the vernal season, is abundantly distributed to the young buds and tender leaves; but if the frosts continue severe, this fluid is repelled or prevented from flowing, and vegetation consequently loses its healthy and natural vigour. The causes which produce these effects are not partial, but general; their influence is modified by one circumstance alone—*the peculiar state of the object on which they act.*

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* An Introduction to the Comparative Anatomy of Animals, by DR. CARUS. Trans. Vol. II., p. 238. See also a Manual of Comparative Anatomy, by BLUMENBACH. Trans. by LAWRENCE, p. 128.

The circulation of blood in animals is liable to be excited or depressed by heat and cold in the same manner as the flow of sap in plants; and unless nature had provided organs capable, from their situation and constitution, of readily receiving a considerable portion of the blood that is determined internally, the lungs, the heart, and the chylopoietic viscera would be too much oppressed by an inordinate quantity of this fluid to exercise their usual functions. It frequently indeed happens, although these organs relieve the oppressed state of the animal system induced by cold, that the powers of life are too much enfeebled to continue in operation. But if there were no organs of this kind, the vital parts of the system would be more frequently disordered, and the effects of their derangement would be of a more fatal character. MANGILI and PARIS, observing the veins and the glands of the throat large and congested in hybernating animals during their repose, endeavoured to account for the phenomenon of torpidity on hypothetical principles, founded on these appearances, which I have proved to be incorrect in the experimental inquiry;* having shewn that they may be easily explained by taking into consideration the influence of cold on the animal body, and the tendency of the blood to flow to those parts of the system in which it meets with the least resistance. An attention to the same causes will also furnish a satisfactory explanation of the apparently great capacity of the congested state of the veins, as well as that of the glands. Since these are so much affected by the determination of blood to the internal organs, it cannot surely be denied that the liver and spleen are at the same time engorged to a degree proportionate to their organic capabilities, which are very considerable; and, if this be granted, it must be admitted, as a necessary consequence, that were there no such organs as these, the whole of that blood which is transmitted to them, would be received by other parts of the system under circumstances that would most probably destroy the possibility of a renewal of the suspended powers of life. Fishes, from the variations of temperature to which their element is subject, and the different degrees of pressure from the weight of water that they bear, according to the various depths to which they descend, require to be furnished with a liver and spleen, or at least with one of them, in order that their oxygenating, propelling, and digestive organs may not be unduly oppressed by changes occurring in the circulatory system. In short, wherever a sanguiferous system exists, and is liable to be affected by mental or physical causes, or by both, there is evidently an absolute necessity for organs capable of receiving the greater portion of the blood, which is occasionally determined internally in an undue proportion. It therefore seems consistent with analogy and facts, to regard the liver and the spleen as *diverticula,* though in ascribing this office to the former, I by no means intend to question its importance as a secretory organ.

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* See Chap. VII.

THE
PHYSIOLOGY OF THE FŒTUS.

CHAP. I.

THE VARIOUS OPINIONS ENTERTAINED CONCERNING THE NOURISHMENT OF THE FŒTUS.

I WAS naturally led to the study of the present subject by the physiological inquiries I recently made respecting some of the most important laws of the animal economy. In the prosecution of these, I endeavoured to shew in what manner the blood is influenced under a variety of circumstances; and by explaining many phenomena, previously deemed inexplicable, or erroneously accounted for, I was enabled to advance a considerable way in elucidating the complex function of the lungs, and also to shew the necessary dependence of all corporeal actions on the regular operation of these organs.* The views I then unfolded tended to correct many erroneous opinions which have been formed in regard to the supposed efficiency of the nervous fluid in the production of animal heat, and the secretion of gastric juice. Appearances make a strong impression on the human mind; but that impression is always deeper when the origin of them is enveloped in mystery. When important effects are explained by a few simple causes, the mind is seldom satisfied with the proofs which are adduced. It continually reverts to the appearances themselves, and fancies that these are too extraordinary to be accounted for on principles which are easily understood.

The great dissimilarity in the character and value of the contributions to science by different individuals, arises probably less from an innate difference in their intellectual faculties, than from the influence of prejudices imbibed in early life, which prevent the impartial exercise of the reasoning powers in the investigation of scientific truths. How often has the progress of physiology been retarded by those who most ardently wished to accelerate it. If the physiologist throw a new light on one department of his subject, it is more than probable that he will darken the avenues which lead to the elucidation of the difficulties connected with another. Ought we, then, to be surprised that physiology has been so remarkably slow in acquiring fixed principles, and has yet been attended with so few practical advantages?

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* Experimental Enquiry into the Laws of Organic and Animal Life.

It is to be regretted that the study of this science has not been more imperatively enforced in medical schools. It has too generally been considered of secondary importance, and hence an exclusive attention has been paid to other branches of knowledge, the principles and relations of which would have been better understood, if an extended acquaintance with physiology had been previously formed.

In reviewing the different opinions which have at various periods been held, respecting the laws which regulate the development of the fœtus, the accuracy of the preceding remarks will be soon apparent. That the subject should have been studied to no purpose before the discovery of the circulation of the blood, ought not to be a matter of surprise; but it is very extraordinary, that this important addition to our knowledge, and the many other valuable accessions which it has received from anatomy and physiology, have not led to the discovery and establishment of more rational principles than were taught by HIPPOCRATES* and GALEN, who believed that the fœtus was nourished by means of the mouth and umbilical vessels — an opinion which was also adopted by HARVEY,† DARWIN,‡

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* Quæ cunque enim incalescunt, spiritum emittunt et alium frigidum vicissim, quo nutriuntur, attrahunt. Atque ex quidem à me adductæ rationes necessariò efficiunt, ut genitura in utero incalescens, spiritum habere et emittere videatur, simulque à matre spirante spirationem habere. Cùm enim mater aërem frigidum ad se attraxerit, eo genitura fruitur." In another part he says:—" Post exactos decem menses, ubi fœtus grandior est, alimentum et incrementum, quod a matre demittitur non amplius puero sufficere potest. Quod enim in sanguine dulcissimum est, ad sese attrahit, simulque aliquantula lactis portione fruitur."—DE NATURA PUERI.

† Initio quidem, per umbilicales radices alitus, plantæ vitam quandam degit; unde corpus crudum, album, atque imperfectum conspicitur; et, plantæ instar, immobile atque iners manet. Quamprimum verò per os eodem alimento ulteriùs elaborato fruitur, quasi spiritu diviniore gaudens, et sublimiore exultans vegetationis gradu, *mucago* dicta in carnis naturam transit, motiva organa distinguuntur, spiritus locupletantur, motúmque orditur: nec jam ampliùs, plantarum more, per radices; sed, animalis instar, per os nutritur, et illius vitam degit. —DE NUTRITIONE PULLI IN OVO. p. 199.

‡ From these facts and observations we may safely infer, that the fœtus in the womb is nourished by the fluid which surrounds it, which, during the first period of gestation, is absorbed by the naked lacteals; and is afterwards swallowed into the stomach and bowels, when these

Bonetus,* and many others. Appearances, which at first seem favourable to an hypothesis, are apt to deceive. The fœtus was observed swimming in a fluid, the origin of which was unknown, and matters of a peculiar kind were also observed in the stomach and intestines. The existence of the waters of the amnios and the indications of a digestive process in the chylopoietic viscera, although extremely trifling and imperfect, induced them to believe that these waters were essential to nutrition, and, were, moreover, received by the mouth. It was maintained by some that such an opinion was much strengthened by the readiness with which a child learns to suck — "Embryo itaque per os victum quærit et sugit. Idque facilè deprehenderis, si ei statim ab utero execto digitum in os immiseris. Quod, teste Hippocrate, nequaquam faceret, nisi priùs in utero suxisset.† Although

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organs are perfected; and lastly, that the placenta is an organ for the purpose of giving due oxygenation to the blood of the fœtus; which is more necessary, or at least more frequently necessary, than even the supply of food.—Zoonomia, vol. I., p. 541.

[*] Id ut pateat, clarius, præsuppono. Fœtum in utero materno nutriri non solum per umbilicum, sed etiam per os juxta Hippoc. Doctrina Harvei.—Segeri, dela Courvée et aliorum. Tom. III., p. 615.

[†] Harvey De Nutritione Pulli in Ovo. p. 190.

HARVEY attributes the nourishment of the fœtus both to the liquor amnii and to the blood derived from the mother, yet it is evident from his reasoning on various occasions, that he attaches the greatest importance to the former.* HOFMANN, on this subject, expresses himself as follows: — "Nutritur infans mediante succo temperato, gelatinoso matris, qui per spongiosam uteri substantiam transcolatur et a secundina recipitur, per cujus vasa ad infantem defertur." The best physiologists of modern times are disposed to regard the placenta as alone necessary for the purposes of fœtal nutrition. DR. MONRO, *Primus,* supports this view with considerable ingenuity, and with that clearness of conception, and vigour of intellect so peculiarly characteristic of him.† MAGENDIE alludes to the very intimate connexion between the mother and fœtus, but, with his usual caution, hesitates in giving a decided opinion.

MAYOW considered the placenta as accomplishing a nutritive process, and effecting chemical changes in the blood. He believed it to be to the fœtus what the lungs are to the adult. This view is also advocated by Dr. Bostock. "We have every reason to believe" observes this physiologist "that the placenta serves the purpose of lungs for the fœtus, and that it performs this office by having its blood brought into close proximity with the arterial blood of the mother, in the same way that the venous blood of the pulmonary artery receives its appropriate change by means of the air which is contained in the vesicles of the lungs." If it were even allowed that the functions of the uterus are analagous to those of the lungs, several considerations seem to shew that the supposed similarity of action does not in the least remove the difficulties connected with the nourishment of the fœtus.

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* Et quemadmodum in ovo gallinaceo, pullus per vasa sua umbilicalia ex albumine alitur; sic etiam fœtus in damis et cervis, ex consimili in his cellulis reservato albumine nutritur non autem ex sanguine.

† Edinburgh Medical Essays, vol. I. p. 290.

Would the organic powers of the adult be invigorated and developed if alimentary principles were not conveyed into the blood? Is the addition of oxygen, or are the changes it promotes, sufficient to maintain life? And whence does the fœtus derive the nourishing properties of food, if its blood is only "in close proximity with the arterial blood of the mother?"*

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* Elementary System of Physiology, vols. II. and III., pp. 201 and 43.

Wilson Philip imagines that the uterus has some wonderful power of generating a fluid, similar in its nature to Galvanism. The idea is borrowed from his views of animal heat and digestion; and this erroneous application of it illustrates the great tendency of the human mind to adapt to its own favourite speculations, the most unlikely circumstances. In reference to the peculiarities of the fœtus, Abernethy candidly acknowledges, that "we really do not know any thing of these peculiarities:" yet notwithstanding this acknowledgment, he affirms, that "the placenta serves the same function with regard to the fœtus that the lungs do in the adult, viz., producing a change in the quality of the blood which was essential for the sustentation of vitality."* M. Geoffroy St. Hilaire has lately read a *memoire in the Academy of Sciences of the Institute,* on the respiration of the fœtus, in which, proceeding on the principle that there cannot be organization without the combination of a nutritious fluid, nor assimilation without oxygenation or previous respiration, he endeavours to shew—

1, That a respirable gas exists in the amniotic fluid, as shewn by the experiments of M. M. Chevreuil and Lassaigne.

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* Lancet, vol. XII. p. 226.

2, That the fœtus, by means of its pores, as by so many tracheas, in the same manner as aquatic insects, is enabled to consume the air contained in the surrounding fluid, owing to the air being thus brought in contact with the venous blood which fills the capillaries of the skin.

3, That the contractions of the womb, and of the abdominal muscles, keep up a certain degree of pressure, which is as requisite to the perfect performance of this process, as to the ordinary act of respiration.*

The liquor amnii has more generally been supposed to be the source whence the fœtus derives its nourishment, than any part of the maternal or fœtal system ; and the opinions concerning the manner in which this fluid is absorbed are not less various, as the following passage will prove, than those which are proposed to explain the nutrition of the fœtus. "Toutefois, les physiologistes qui ont admis cette source de matière nutritive ont différé sur la voie par laquelle ils l'ont fait penetrer; tours-à-tours ils ont indiqué la peau, l'appareil digestif, l'appareil respiratoire, les voies génitales, les mammels. BUFFON, OSIANDER, VANDENBOSH, ont fait absorber la liqueur del' amnios par la peau du fœtus."* In the London Philosophical Transactions for 1829, there is a communication from Dr. LEE, on the subject of fœtal nutrition. He attempts to shew that the liver is a secretory organ of albumen during fœtal life, and, moreover, that this contributes to the nourishment of the child *in utero*.

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* Med. Repos. New Series, 1824.

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* Adelon Physiologie Del' Homme, Tom. IV. p. 388.

CHAP. II.

THE PRIMARY AND SECONDARY FUNCTIONS OF LIFE.

It is not, on all occasions, easy to understand the mysterious operations of the animal economy; but when they are examined with care, a few important facts are gradually discovered, which serve as certain fixed points of light, to direct our further investigations, and to clear up the obscurity that envelopes them. In the multiplicity of organs of which the system is composed, and on all of which its health, more or less, depends, supposing that they all merit an equal consideration, we are apt to be perplexed in endeavouring to ascertain those which are of *primary*, and those which are of *secondary* importance. If we succeed in distinguishing the proper office of each organ, we shall perceive that some have a *direct*, and others an *indirect*, influence in producing one great result, viz., the nourishment of the body. The brain and the spinal cord are essential to intellect, sensibility, and motion, which are properties of animal life; but they are not indispensably necessary to the functions of organic life. A part of the motory nerves is employed in the process of respiration, regulating the ingress and egress of air into and from the lungs; but direct experiments have shewn, that these actions are performed, and the chemical changes of the blood effected, as in the natural order of things, when the influence of the motory nerves is destroyed, providing the introduction and expulsion of air be secured by the insertion of a small tube into the divided trachea.* Satisfactory proofs, in confirmation of this opinion, are also derived from fœtuses born without the first mentioned organs, whose system is otherwise perfectly strong and healthy. The lowest gradations of animal life are destitute of these organic instruments, but they have others in harmony with the simplicity of their organization, which conduce to their nutrition and development. It will appear from subsequent observations, on some of the laws of the vegetable kingdom, that the same general contrivances for the preservation of existence are found in every animal and vegetable production. Life, through every link of creation, is maintained by similar designs. "Nature never oversteps the bounds which the necessary conditions of existence prescribe to her; but whenever she is unconfined by these conditions, she displays all her fertility and variety. Never departing from the smallest number of combinations that are possible, between the essential modifications of important organs, she seems to sport with infinite caprice in all the accessary parts. In these, there appears no necessity for a particular form or disposition. It even frequently happens, that particular forms and dispositions are created without any apparent view to utility. It seems sufficient that they should be possible; that is to say, that they do not destroy the harmony of the whole. In proportion, therefore, as we turn our attention from the principal organs to those which are less important, we discover increasing variations; and when we arrive at the surface of bodies, where the nature of things requires that the parts least essential, and the injury of which is least dangerous, should be placed, the number of varieties becomes so considerable, that all the labours of naturalists have not yet been able to give us an account of them."* Additional organs are bestowed on the animal of more complex construction, that it may answer the varied purposes for which it was intended. What these purposes are, and how far they are accomplished, it is not my present object to describe. The brain, the spinal cord, and the heart, afford a striking illustration of the additional organs which have been given to the most perfect animals. These organs do not, in the least, directly contribute towards the production and elaboration of nutritious matter; and therefore, they may with propriety be regarded as of *secondary*, and not of *primary* importance. The different excretions remove a variety of substances unessential to the system, which, if retained, would disorder those functions that create, distribute, and assimilate the nourishing properties of food. Most of the excretory organs have been added to the more perfect forms of organization, for purposes of a *secondary* nature, in regard to the production of the pabulum vitæ, but of vital consequence with respect to the continuance of life, from the very intimate relations existing between them and other organs which produce excrementitious matter.

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* Experimental Enquiry, Chap. x.

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* Lectures on Comparative Anat., by Baron CUVIER, vol. II. p. 58.

Motion of every kind, whether displaying itself in the constant or periodical contractions of the internal organs; the graceful or violent action of the limbs and body; or, indeed, in any way that indicates life, is peculiarly characteristic of the animal kingdom; and its degrees and variety are proportionate to the organization of the individual, and the necessities of the place it occupies in creation. The senses have been given to animals, for the purpose of making them better acquainted with the external world, and enabling them to select those objects that are grateful and essential to life, as well as to avoid those that are disagreeable and injurious. "The eye presents to the light, transparent lenses which refract its rays. The ear offers to the air, membranes and fluids which receive its concussions. The nose inhales the air which is to go to the lungs, and seizes, in their passage, the odoriferous vapours it contains. Finally, the tongue is covered with spongy papillæ, which imbibe the savoury liquids that are taken into the mouth."

As the number and perfection of senses each animal possesses increase, they appear of greater importance as inlets of pleasure and knowledge, and of less consequence as organs necessary to existence.

> Invenies primis ab sensibus esse creatam
> Notitiam veri; neque sensus posse refelli:

> Nam majore fide debet reperirier illud,
> Sponte suâ veris quod possit vincere falsa.
> Quid majore fide porrò, quàm sensus haberi
> Debet? an ab sensu falso ratio orta valebit
> Dicere eos contra, quæ tota ab sensibus orta est?
> Qui nisi sint veri, ratio quoque falsa fit omnis.
> An poterunt oculos aureis reprehendere? an aureis
> Tactus? an hunc porrò tactum sapor arguet oris?
> An confutabunt nares, oculive revincent?*

The fœtus has not in activity any one of the senses, yet the mere animal exists, and the numerous organs are developed which support the system after birth.

From these cursory observations we are prepared to understand the functions of those organs which are called *primary*, namely, *the stomach, the liver, the pancreas, and the various glands that in any way contribute towards the elaboration of food.* Although these organs are distinguished by different actions and properties, yet they are all equally labouring to produce one indispensable substance, namely, chyle. This fluid bears the same relation to the animal, that sap does to the vegetable system.

It is by means of chyle, that the continual wastes of the frame are compensated; that every part of the organized being is more fully developed in the period that elapses between infancy and manhood; and that the various powers of life are invigorated and enabled to continue their operations, amidst extensive and constant changes, with unabated energy. But chyle is not calculated to answer any of these purposes, until it has passed through the lungs. *The body can receive no nourishment whatever from any substance, unless this has undergone certain modifications in these organs.* What the precise changes are, which are produced upon it, are unknown; but there is little doubt, that they are chemical and various in their nature. The ascending sap, until it has been acted upon by atmospheric air, is no more calculated to contribute to the nourishment and vigour of the tree, than chyle, before it has been exposed to the influence of the same renovating principle, is adapted to preserve and sustain animal life.

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* Lucretius, Lib. IV. v. 480—490.

The general principle, as applied to both the animal and the vegetable world, is clearly ascertained, and as regards the latter, receives abundant confirmation from the fact, that trees occasionally decay, from not possessing a more extensive surface of leaves, to expose fully the sap within them to the action of the air;

or from their receiving a greater quantity of it than can be perfectly oxygenated.*

The superior surface of the leaves is requisite to present the moisture derived from the roots to the influence of the atmosphere; and the qualities of the sap thus purified, like those of arterial blood, are necessary to support life.

The lungs, and all parts of the animal frame, formed for a similar purpose, perform the same office, and are called *primary* organs. *Whether nutritious substances be absorbed by the skin, the intestines, or the veins, it is evident, from the preceding observations, that they cannot be considered to possess vital properties, until they have undergone certain chemical modifications.* The stomach, the liver, and the pancreas, are bestowed in order to produce chyle; and this is the only fluid which is capable of supplying the various wants of the system; but neither this fluid, nor any analogous to it in the animal or vegetable kingdom, is adapted to answer the important purposes of existence, until it has experienced the action of the air. In infancy, the appetite is keen, and the stomach quickly digests the food which it receives, whilst the remainder of the *primary* organs contribute, in an equal degree, towards an abundant production of chyle. At this age, the respiratory function is, also, extremely active, and consequently produces a more complete oxygenation of the blood than at any other period of life. The vigorous state of the bodily organs, and their great activity in early life, sufficiently account for the growth of the child, and the excess of its animal spirits. The frequent beatings of its pulse show that the sanguineous fluid is favourably situated for extensive chemical changes; and, in corroboration of the opinion that such take place, it may be remarked, that the venous blood of a healthy infant is more florid than that of an adult, and its temperature also, in general, much higher.* The child has a greater proportional quantity of the principle of life, than one even in the prime of manhood; because those organs which nourish it are more active, and are seldom or never affected by depressing feelings of the mind, or pernicious irregularities of conduct.

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* Phil. Trans. for the year 1810. Part II. p. 178.

The constant tendency of the child to indulge in sportive amusements, such as running and jumping, and in violent emotions, such as laughter and crying, together with the natural restlessness of its mind, and the hilarity of its feelings, all creating strong muscular action, is to be attributed to its greater susceptibility of impressions of every kind, and the better oxygenation of its blood. The eye is continually delighted with new appearances, and the ear charmed with agreeable sounds, which never fail to excite an interest in surrounding objects, that is always accompanied by muscular conditions of the body.*

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* Experimental Inquiry, Chap. V., p. 121.

> " Dum mens alma caput cerebrique palatia celsa
> Occupat, et famulos sublimis dirigit artus,
> Et facili imperio nervorum flectit habenas,
> Illius ad nutum sensus extranea rerum
> Explorant signa, et studio exemplaria fido
> Ad dominam adducunt; vel qui statione locantur
> Vicinâ, capitisque tuentur limina, ocelli,
> Naresque, auriculæque, et vis arguta palati;
> Vel qui per totam currit sparso agmine molem
> Tactus ad extremas speculator corporis aras."

Vegetation in spring and summer exhibits organic adaptations, in activity and character, similar to those which distinguish the growth of the body in infancy and childhood. As soon as the genial heat of spring has loosened the earth, and slightly stimulated the vessels of the plant, its tender buds are gradually formed, and quickly expand into full leaf. At this time, when the whole plant is covered with leaves, the principle of vitality is extremely energetic, and the effects produced by it chiefly arise from more extensive changes of the sap, in consequence of its being diffused through a larger surface of leaves spread out to the invigorating warmth of the sun. The excess of vitality is not spent altogether in extending the growth and vigour of the tree, but in enriching it with flowers, preparatory to the evolution of fruit. From this cursory view of the respiratory organs of the vegetable, and of the changes which they effect, it appears that its adaptations to promote chemical action are of the same nature as those which belong to the animal world; and still further, that the production of the phenomena which succeed the operation of atmospheric air, is regulated by the same principles as that of those with which the Supreme Being has endowed his more distinguished creations. The rapidity with which the blood circulates through the lungs, and the frequent renewal of atmospheric air in infancy and childhood, are invariably accompanied by certain general effects which are readily traced to their immediate causes.

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* " In the morning of our days," observes an elegant writer, " when the senses are unworn and tender, when the whole man is awake in every part, and the gloss of novelty fresh upon all the objects that surround us, how lively at that time are our sensations !"

The causes which produce the vigour and health of the animal system in infancy and childhood are evident to all: nor less apparent are those which are productive of similar effects in vegetables. Man has only one period of infancy and childhood, during which the various organs of his body are sufficiently developed for the purposes of his being;—but the vegetable displays every year in the renewal and fall of its verdure, the extremes of youth and age. In spring and summer the perennial plant is as young and blooming in appearance at the tenth year of its existence, as it was at the second, because certain peculiarities of organization never fail to return at these seasons, such as an extended surface of leaves, and an increased circulation of sap, to which, and not to the influence of any mysterious cause, the exuberance of its vitality is principally to be ascribed. If the warm and reviving rays of spring are suddenly succeeded by cold bleak winds, the expansion of the few buds, which had been allured forth by the warmth of the atmosphere, is quickly repressed. Warmth stimulates the capillary vessels of the leaves or plant to augmented action, under the invigorating influence of which—an influence communicated to every part of the vegetable system—the root absorbs a greater proportion of moisture; and as every particle of this moisture must be subjected to chemical changes in the leaves or analogous organs, before it acquires the properties of nutrition, it is obvious that the extent of these changes will depend entirely *upon the surface of leaves exposed to the day, in the same way as the functions of organic life are influenced by the size or activity of the respiratory organs.* Although many of the inferior animals do not possess lungs, yet, however low in the scale of being they are placed, they have instruments fitted to perform the same end. "The mode in which the breathing organs of the *toredines* are supplied with water, makes it evident that all sea-worms which have no cavity for the reception of sea-water, must have the breathing organs placed externally, as is the case with all those species of *actinia* met with in the West Indies, called *animal flowers,* and the beautiful membranous expansions they display, resembling the petals of flowers, are in fact the breathing organs acting at the same time as *tentacula*."

If warmth, by exerting on the plant the influence already described, has a tendency to excite and invigorate its energies; cold, by lessening the capacity of the capillary vessels, will depress and enfeeble those energies, and in proportion as this latter effect is produced, the quantity of sap previously brought to the leaves, will be gradually diminished, whilst its properties will also be less stimulating; in consequence of which, the absorbent powers of the root will be as directly affected, as the absorbent and excretory functions of the leaves. The analogies which exist between the animal and vegetable kingdoms, in respect to the general laws of nutrition, and the process of respiration, are so remarkable, that I have been induced to state them more fully than the nature of this physiological treatise may seem to demand. It appears that the differences which characterize these laws, are not to be referred to the general principles which tend to nourish and develope, or to chill and repress the animal and vegetable in the several periods of their existence, and the various seasons of the year, but to the nature of those instruments by which these ends are accomplished. Some of them are necessarily complex, from their connexion with important organs, or from the diversities in the forms of the more perfectly constituted animal.

These views, which show the comparative simplicity of many vital operations in both kingdoms, are more consistent with reason, and accordant with observation and experiment, than the brilliant, but imaginary hypotheses, which suppose a nervous fluid, or some similar power, to exert a marvellous influence over the organic actions of the animal system, and to regulate those in the vegetable.*

With how much satisfaction we sometimes imagine to exist what cannot be perceived, and talk learnedly about that, the very being of which cannot be proved! When we attempt to form systems on suppositions, which are either altogether fanciful, or founded on imperfect observations, how unsubstantial and useless is the superstructure we erect upon them!

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* If the experiments which have been laid before the reader be correct, the sensorial functions constitute the animal, and the nervous and muscular organic life. To this it may be objected, that plants, and the less perfect animals, have no nervous system. Would it not be more correct to say, that the operation of their nervous system is more confined? Wherever secretion is performed, the nervous influence, or a power resembling it, must exist.—PHILIP on the Vital Functions, p. 216.

Future discoveries cannot diminish the value of original contributions to the stores of scientific knowledge, derived from investigations into the visible operations of the animal and vegetable systems—operations which the mind is capable of examining, and which alone furnish any safe ground for satisfactory inquiries. "When we go," observes BURKE, "but one step beyond the immediately sensible qualities of things, we go out of our depth. All we do after is but a faint struggle, that shows we are in an element which does not belong to us."*

This mode of investigating the works of nature differs materially from that which has in all ages more or less been adopted by physiologists, who have generally manifested a greater desire to discover the occult powers of life than to study them. Oxygen is essential to the existence of every thing that breathes or vegetates, and is one of the great sources of vital energy.

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* Philosophical Inquiry into the origin of our ideas of the Sublime and Beautiful. Part IV., Sect. I.

I regard it as intimately blended with the different substances which the blood contains. It enters into or facilitates, by the affinities it creates, the various combinations of the sanguineous fluid and all other fluids of the body; and if we consider that the nutriment which the vegetable absorbs from the earth, and the food which we take, possess various chemical formations, it will not appear improbable, that the variety or perfection of them is, in a great measure, to be ascribed to the direct or indirect influence of oxygen, as it is the most general, active, and pervading principle in nature. From the preceding considerations we may conclude :—

1. That the principles which regulate the nutritive process in the animal system are of the same kind as those in the vegetable.*
2. That the exuberance of vitality in infancy and youth, and its deficiency in old age, are the effects of the same physical causes, which give foliage and blossoms to the plant in summer, and which prevent the development of them in winter.

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* The description which VIRGIL gives of the changes that occur in spring, in the animal and vegetable kingdoms, shews how much the genial influence of this season affects both.

> Vere tument terræ, et genitalia semina poscunt.
> Tum pater omnipotens fœcundis imbribus Æther
> Conjugis in gremium lætæ descendit et omnes
> Magnus alit, magno commistus corpore, fœtus.
> Avia tum resonant avibus virgulta canoris;
> Et venerem certis repetunt armenta dìebus.

3. That the means which nature employs to effect these various purposes differ only in degree.

4. That the ascending sap in plants is similar to the chyle in animals, unfit for nourishment until it has been acted upon by atmospheric air ; and that the descending sap, from the nutritive properties which it possesses, bears a striking resemblance to the arterial blood, the great source of vital actions.

5. That the animal system cannot derive nourishment from any substance, unless it passes through the lungs ; and still further, that the extent and perfection of assimilation will, in a great measure, be regulated by the extent and perfection of the chemical changes which the blood undergoes in the respiratory organs.

6. It is also manifest, that there are no organs of the body, except the lungs, which can, under any circumstances, produce chemical changes in the circulating fluid ; any more than the bare trunk is capable of effecting in the tree those similar changes, which in summer are produced by its numerous leaves. The lungs are, therefore, to be regarded as the only cause of animal heat and of those chemical changes which the blood undergoes in passing from venous to arterial.

CHAP. III.

THE NATURE OF FŒTAL LIFE.

THE striking difference that exists between the circumstances in which the human embryo is placed, as well as the degree of development it attains during the first few weeks after conception, and those of the completely organized fœtus, are of sufficient importance to form an essential distinction between embryotic and fœtal life. — The term embryo is employed here to designate a being yet so imperfectly constituted that few of its organs are formed, whereas, fœtus is a denomination given to a being possessed of the principal organs which the animal exhibits when arrived at a state of maturity. — To a neglect of this distinction must be attributed the discrepant opinions which have, from time to time, been adopted to explain the nutrition of the fœtus.

Those, who endeavoured to shew that it is entirely supported by the maternal blood, found a difficulty in accounting for its nourishment and growth during the time previous to a connexion being established between the uterus and the chorion ; others, who advanced a different opinion, were inclined to think that the fœtus is altogether indebted for its nutrition to the fluids in which it is immersed. In support of the latter supposition it is stated, that these exist at a period when it cannot possibly have other means of sustenance.

Our knowledge of the mode in which the human embryo is generated is very limited and imperfect, but the reasoning I shall employ, in pointing out the different provisions which nature has furnished for the maintenance of embryotic and fœtal life, requires no deep insight into the mysteries which envelope this subject. — When the embryo is observed about the third week "il est alors," as ADELON remarks, "oblong, vermiforme, renflé à son milieu, obtus à l'une de ses extrémités, terminé en pointe mousse à l'autre, droit ou faiblement courbé en avant. — Il n'est alors qu' un petit corps gélatineux, d'un blanc grisâtre, demi-opaque, sans consistance, long de deux à trois lignes, et du poids de deux à trois grains. — Il est réduit au torse ; il n'y a pas encore en lui trace dela tête, on voit seulement en avant une petite saillie séparée du reste par une entaille."*

The ovum which is found in the uterus immediately after impregnation, possesses within itself not only the principles of vitality, but fluids which are appropriated to the purposes of organization. The way in which these are modified, so as to assume a determinate form, is one of the secrets of nature, with which we are, and probably shall ever be unacquainted, but it cannot be denied that the diversified forms they assume are the result of vital operations. A vascular connexion, at this time, with the uterus, would be of no service to the embryo, because there are no internal organs sufficiently developed to receive and distribute the blood, until the rudiments of a circulatory system exist; the sanguineous or any other fluid which might be derived from the uterus could not be applied to the formation of the embryo, but the warmth and moisture which the uterus possesses are perhaps as essential to its growth as the warmth communicated to the egg during incubation. When the vital actions have proceeded so far in the organization of the fœtus, as to create, although imperfectly, the heart, the vena porta and the aorta, the umbilical cord may be distinctly perceived, and it very soon establishes a connexion between the chorion and the uterus.* When this union is fully established the embryotic is changed into fœtal life, and the latter is exclusively nourished by the arterial blood of the mother.

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* Phyisologie del 'Homme par ADÉLON. Vol. IV. p. 343.

A succession of phenomena of the same kind occurs during the incubation of the egg. In this case, as in the preceding, the embryo is the production of similar causes, appropriating to the purposes of organization the nutritious matter immediately surrounding that part of the yolk-bag called the *nidus pulli*;† but as soon as the most important abdominal organs are visible, a vascular membrane, *chorion,* begins to form about the navel, and increases in a few days to such an extent, that it covers nearly the whole inner surface of the shell, within the *membrana albuminis* during the latter period of incubation. This organic contrivance is of no use until the embryo is sufficiently formed to receive the blood which it aerates.

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* ADELON, Physiologie del 'Homme, vol. IV. p. 345.

† BLUMENBACH's Manual, trans. by LAWRENCE, p. 371—2.

From these observations, it is evident, that it is necessary to make a distinction between embryotic and fœtal life, in accordance with the meaning which has been attributed to these terms, and from the principles which have been developed in the preceding chapter we are now prepared to enter upon the investigation of the latter. I have endeavoured to shew, that whatever is received by the animal and vegetable, cannot be considered as nutritious until it has undergone certain modifications in the lungs, leaves, or analagous organs. This fact is highly important. The light which it throws on the present subject will enable us to detect the fallacy of a variety of opinions in regard to the principles which regulate fœtal nutrition.

If the foregoing remarks be correct, it cannot be denied that there are two great classes of organs continually employed in maintaining animal existence, which have no other immediate office. — The *first* class includes those organs which are incessantly labouring to support the body, as the stomach, the liver, the pancreas, and the lungs. — The *second*, the whole of the excretory organs which contribute indirectly towards the proper action of the former. The first may be regarded as causes, the latter as effects.

As the number of those organs which produce chyle is increased according to the ascending gradation of animal life, or as their various actions are accelerated, the number or activity of those which remove from the system excrementitious matters is proportionably augmented. If a quantity of food be taken, greater than what is usual, the excretions of the kidneys, intestines, skin, or lungs, or probably the whole of them, are increased in degree equal to the activity of the *primary* organs. The object of these organs is either directly or indirectly to form chyle or rather arterial blood. If this fluid were received from without the system, it is evident *that the lungs, the liver, the stomach, and the pancreas, and indeed all those organs which promote the elaboration of food, would be entirely superfluous, and that there would be no occasion whatever, for the brain or spinal cord as connected with the function of respiration.* The excretions would in this case still continue, but would be considerably less in quantity. This mode of viewing the subject enables us, at a glance, to discern the real character of the various functions of organic and animal life, as also, to form a correct idea of their relative importance. Fœtal existence is frequently likened to that of a vegetable, but there is no analogy whatever between them. The vegetable, from the activity of its own functions, selects and absorbs appropriate food; but the fœtus is not at all employed in providing for its own wants. What is essential to its support is prepared by another. The opinion that the fœtus is nourished by means of the amniotic fluid received by the mouth, would unavoidably lead us into great absurdities. Supposing it to be supplied with this fluid in the manner stated, certain effects evidently arising from the changes it undergoes ought to be apparent in the stomach. It has been already shown how fluids become nutritious. In investigating the subject, we found that several organs were essential to form chyle. It was also remarked, that whenever it is produced by the *primary* organs, those which belong to the extensive class of excretions are, also, necessarily active. If the former contribute an abundant supply of nutriment, the latter will be required to exert themselves to an equal extent in removing all excrementitious matter. It is absurd to suppose that anything, received by the stomach, can, without undergoing the usual modifications of food in this organ, be applied immediately to the support of the system. It has been observed, that the ascending sap, until it has passed through certain important changes in the respiratory organs of the plant, is not adapted to supply its wants. It has also been shown, that whatever supports the animal system necessarily undergoes a similar process in the lungs before it becomes nutritious, *and that this process is always accompanied by a variety of excretions commensurate in quantity with the action of those organs that produce chyle.* It is therefore evident, that the fœtus is not nourished by the amniotic fluid: if it were, the liver, the pancreas, and the stomach would be almost as vigorously exercised, as they are immediately after birth, when the intestines, kidnies, lungs, and skin, most actively perform their several offices. The fœtus cannot possibly breathe by the mouth, neither does it evacuate fœcal matter to permit successive accumulations of it in the bowels, which are not burdened by any excrementitious matter.

If we even allow that the amnios, from its great purity, does not require to be considerably changed in order to be converted into chyle, it is nevertheless true, that the modifications it undergoes, however slight they may be, would, during the period of fœtal life, create an abundance of the different excretions. The Meconium which is found in the intestines does not possess the peculiar qualities of alvine evacuations. That the amnios serves the purposes of nutrition, is an idea that cannot for a moment be entertained, when we consider the changes to which chyle must, according to the statements already made, be necessarily exposed in the lungs before it can acquire the properties of aliment. From the principles previously stated, it appears unreasonable to suppose, that assimilating operations are continually going on, unless it be also allowed, that they are invariably accompanied by a proportionate exercise of the excretory organs.

It is the general opinion of physiologists and anatomists, that the thoracic duct of the fœtus does not contain chyle. "Some persons," observes MAGENDIE, " say they have seen chyle in the thoracic duct of the fœtus; I have never seen anything of the kind; in living animals, this canal and the lymphatics contain a fluid analogous to lymph, and which, like it, coagulates spontaneously."* The veins are then the only channels through which the nutriment derived from the amnios can be conveyed to the heart and lungs; but, if it were even admitted, that a small quantity, or the whole of it passes through the thoracic duct, the subject would still be involved in the same difficulties. The qualities of the blood, as it circulates through the thoracic organs of the fœtus do not undergo any alteration whatever; and therefore, if a fluid, crude and unelaborated, were continually combining with it, the vital properties of the blood would be rather injured than improved. This mode of reasoning proves also the incorrectness of the opinion which is held by some physiologists, that the fœtus receives venous blood only from the mother. If the amnios, from its great purity, be considered as peculiarly fitted for the function of assimilation, this supposition does not, as before remarked, increase the probability of its contributing to this process; but we shall now endeavour to examine the grounds for believing that it is, in any degree, adapted to answer such a purpose.

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* MAGENDIE's Physiology, transl. by Dr. MILLIGAN.

The amnios is said to be secreted by the membranes which contain it, and is consequently derived from the blood. Two extensive classes of substances, differing very much in nature, are formed from this fluid. *The bile, the pancreatic and gastric juices, belong to this class.* These produce important changes in the food; but unless it be supplied, they cannot create chyle, which is the only source of animal nourishment. *The excretions of the kidnies, skin, and lungs, constitute the other class.* The animal economy does not afford one example of the blood secreting what is nutritious for the purpose of being again absorbed and appropriated to the support of the system. The arterial blood possesses what is requisite to satisfy the wants of the body, and this is directly communicated to organs, whose office it is to maintain the powers of life; its nutritious properties are not poured into a bag-like receptacle to be received by vessels and again mixed with the contents of the stomach and intestines.

Towards the close of fœtal existence the amnios becomes thick or loses its transparency, and also frequently emits the odour of urine. Does it seem probable that this fluid is intended to nourish the fœtus? Is there any similitude whatever between it and the bland secretion of the breasts? The amnios, in certain cases, continues to escape *per vaginam* for several weeks previous to the full period of parturition, and yet the fœtus, during the whole of this time, is well nourished. It is stated by some, that the mouth of the fœtus is generally open, which would seem, as they imagine, to strengthen the opinion that it is entirely supported by the amnios; but, if the fact of the mouth being open proves that this fluid is regularly transmitted to the fœtus, what is the cause, since it has this favourable opportunity of flowing in a continuous stream, that the stomach and intestines are not filled with it? The fluid, however, which these viscera do contain, is small in its quantity, and perfectly *sui generis.* There is, moreover, another objection to the preceding opinion, arising from the fact that a person destitute of sensorial sensibility (and the fœtus has none,) cannot exercise the function of deglutition. If he is in a state of torpor either from intoxication, or any other cause, he has not power to swallow anything whatever. The *nutrition* of the fœtus cannot certainly be influenced by impressions communicated to the brain, because, in it, this organ is insensible to them. Motion is displayed by the fœtus, which might lead the hasty observer to suppose that it demonstrates the sensibility of the brain ; but this phenomenon is as strongly manifested when the brain is wanting, or defective, as when it is quite perfect.* If hunger were felt by the fœtus, it would most probably cause an action in the organs of deglutition ; but as the desire of food is a sensation of the mind, and indicates, like the faculty of reflection or attention, a wakeful state of the sensorium, it cannot with propriety be said to exist at this time. This sensation is principally occasioned by an expenditure of corporeal energies, or the absence of aliment from the stomach. The fœtus is not subject to any waste of its powers similar to that which takes place in adults, *and therefore cannot have periodical desires.* It is almost unnecessary to make any further remarks on the evident fallacy of opinions founded on the supposed nutritious properties of the amnios.

An apology would be due to the reader, for having occupied so much of his time, were it not that the views I have examined are still maintained by physiologists of eminence. Geoffroy Saint Hilaire, to whose doctrine I have before alluded, entertains a very peculiar opinion on this subject—an opinion even more chimerical and untenable than any which I have already considered. He supposes the amnios to contain a respirable gas, which is constantly absorbed by veins in contact with the fluid. He seems to imagine, that the only substance which the fœtus requires for the development of its numerous organs is oxygen. The capillaries of the skin, according to his fanciful hypothesis, are filled with *venous* blood, which, from its favourable situation, readily absorbs oxygen from the amnios and becomes arterial. *If the adult were possessed of an arterial and venous system, but deprived of the contributions of the digestive organs, would the exercise of the respiratory function increase or maintain the muscular powers of the body, cause a deposition of fat, and produce the various actions of the animal economy?* Such an idea would lead one to suppose that the only difference between arterial and venous blood is in the former containing oxygen. The following observations by Legallois bear directly on this subject, and their correctness can scarcely be called in question :—"Que cette combinaison des sangs veineux entre eux, et avec le chyle et la lymphe, ne permet pas d'admettre, avec quelques physiologistes, que le chyle est déposé dans le parenchyme pulmonaire, repris par les lymphatiques et reporté au cœur, puis rapporté, déposé et repris de nouveau dans les poumons jusqu'à ce qu'il ait subi une élaboration complète, tant dans ces viscères que dans les glandes bronchiques; que cette même combinaison des sangs veineux et des sucs chyleux et lymphatiques est une des conditions, une des circonstances nécessaires à la reproduction du sang artériel, qui reçoit ensuite dans les poumons sa dernière façon, si je puis m'exprimer ainsi. C'est cette combinaison qui détermine les proportions des principes de ce sang."*

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* Magendie's Physiology, transl. by Dr. Milligan, page 195. Edit. II.

The various organic contrivances to secure the influence of oxygen on the circulating fluids, in the lowest gradations of animal life, show the importance of this principle; and the more extensive and accurate our knowledge becomes concerning it, the less prone we shall be to attribute to nerves galvanic or other peculiar properties as the efficient agents in all organic actions. Oxygen, although possessed of extraordinary powers, is to be considered, not as directly, but as indirectly promoting nutrition. It produces those changes which are essential to life, in whatever supports the animal and vegetable system. We shall err as much in supposing it to be the only valuable agent in the economy of nature, as in believing it to be of secondary importance. The venous blood of the adult is not nourishing merely in consequence of its becoming oxygenated, but also of its continually acquiring chyle, and undergoing certain modifications in the lungs. To reason otherwise, argues an imperfect acquaintance with the laws that regulate the operations of animal and vegetable life. That the amniotic fluid contains a respirable gas, is a fact proved, according to the statement of GEOFFROY SAINT HILAIRE, by experiment. Is it not more than probable, that analytical processes to ascertain the exact composition of a fluid, discover not only what it possesses in its natural condition, but likewise disengage gases that were previously in combination with its different chemical principles? If it were even allowed, that the amnios contains a respirable gas, insuperable difficulties are connected with its production and mode of action. It is imagined to be taken up by the pores of the skin, which act like so many tracheas. *If these have sufficient energy to absorb, the skin must also be able to secrete: the two functions must coexist. What becomes of the secretions? As they are necessarily poured into the amniotic membrane, they must continue to accumulate from the commencement of fœtal life to its completion; and therefore, it is improbable to suppose, that a pure oxygenating principle could exert any influence under such circumstances.*

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* Œuvres de LEGALLOIS, Vol. II., p. 205.

We now come to the consideration of an opinion almost universally held by physiologists, that the placenta is capable of oxygenating the blood it receives. "We find," says Dr. Bostock, "that the blood which is sent from the fœtus, along the umbilical cord, to the placenta, in the venous state, is returned in the arterial state; so that we are justified in concluding, that this organ supplies the place of the lungs, or produces the chemical changes in the blood, which fit it for the support of life."* Harvey, Mayow, and many other distinguished physiologists, entertained a similar idea concerning the office of the placenta.

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* Elementary System of Physiology, Vol. II., p. 201.

"The fœtal blood," says Sir E. HOME, "is close enough to that in the vessels of the uterus, to have the air in the maternal blood communicated to it. From the series of facts which have been detailed, it appears that oxygen is essentially necessary for the action of the vivifying principle in all classes of animals; and that it is not simply applied to the blood, but mixed with that fluid while circulating in the arteries."* The whole investigation resolves itself into an inquiry concerning the analogy existing between the lungs and the placenta. It has already been shown, that the lungs of animals, and the leaves of trees, answer similar purposes. Nutritious matter, the product of other organs, is conveyed to both, in order that they may undergo certain chemical changes. *These are produced by atmospheric air, and by the ejection of what is excrementitious.* We have not the least evidence, that actions of this kind can ever take place, unless the organs which effect them, have the same relations to the external world, as the lungs of animals, or the leaves of plants. We might as reasonably expect, that the kidneys would, under peculiar circumstances, secrete bile, and the liver urine, as that blood can be oxygenated without possessing its ordinary organic conditions. The placenta does not exhibit one single property which can justify the physiologist in comparing it with the lungs. Its texture is widely different, and its situation and relations are as dissimilar, as it is possible for those of any two organs to be. Is an extraordinary galvanic or nervous influence connected with the placenta, and exercised in a mysterious manner during gestation ? Unless we believe in the existence of such an influence, it is absurd to suppose that the placenta is capable of aërating the sanguineous fluid. It may be stated, as a universal law, that whenever venous becomes arterial blood, *air is received directly from without, and whatever is excrementitious is expelled directly from within.* If venous blood be placed in a bladder, it becomes florid in appearance. In this case, oxygen disappears, and carbonic acid is formed. But how can the placenta improve the qualities of blood, without oxygen, and the concurrence of those organic adaptations which characterize the respiratory organs throughout the animal and vegetable kingdoms! Can the blood act upon itself and cause such an effect? If the placenta oxygenate the blood, whence does it derive the necessary power, and how does it remove the excrementitious product? If it be acquired from the arterial fluid circulating in the uterus, whence does it derive the properties of nutrition? The observation of Sir E. HOME seems to imply, that air only is received from the mother. "The fœtal blood," he says, "is close enough to that in the vessels of the uterus, to have the air communicated to it." It has been remarked, in the preceding pages, that venous does not become arterial blood, merely from the influence of oxygen, but from its qualities being continually renewed by chyle.

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* Phil. Trans., 1810, p. 216.

A new hypothesis has lately been formed by Dr. LEE, to explain the nutrition of the fœtus. He endeavours to prove, that the liver of the fœtus secretes an albuminous fluid, which is absorbed by the smaller intestines, and contributes to the support of the system. "The stomach of the fœtus," he observes, "I usually found, in these cases, distended with a semi-transparent, ropy, mucous, and occasionally acescent fluid, without any sensible admixture of albuminous, or other apparently nutritious matter. In the duodenum, and part of the remaining portion of the small intestines, there was uniformly present, adhering closely to the mucous membrane, a semi-fluid matter, found, upon examination, to possess properties decidedly of an albuminous character, and to have an orange or pink colour. This matter has always been found in greatest abundance around the papillary projection, through which the common duct of the liver opens into the duodenum. My attention was next directed to discover the source of this albuminous matter in the intestines, which, I conceived, could only be derived from the pancreas, the liver, or the duodenum itself. With respect to the pancreas, that organ remains so small, during the whole of the fœtal state, that it would appear incapable of forming so large a quantity of matter as exists in the intestinal canal. On the other hand, the duodenum presents still greater difficulties to the solution of this question ; for it seems improbable that this portion of the alimentary canal can perform simultaneously the office of secreting and absorbing the same matter ; to say nothing of the anomaly which, in this case, would take place, of a mucous membrane forming albumen. From having observed, in every instance, the same orange-coloured fluid, in the small intestines, collected in great abundance near the orifice of the ductus communis choledichus, and taking into consideration the magnitude of the fœtal liver, and the large supply of blood which it receives from the umbilical vein, it appeared to me reasonable to infer that this viscus must be the source of the matter in question."* In examining impartially the merits of this hypothesis, we shall find it as unphilosophical and untenable, as those opinions which have hitherto been entertained on the same subject. 1st. In regarding the liver as an organ secreting the albumen, Dr. Lee does not appear to take into consideration the absurdity of attributing to an organ, two such opposite functions, as the secretion of albumen one moment before birth, and of bile the next moment. The peculiar secretion of an organ is not regulated by the quantity of blood it receives, but by its structure. Every organ, throughout the animal economy, has an independent and exclusive

* Phil. Trans., Part I., 1829.

function. The difference between the properties of albumen and those of bile, is as great as between any two secretions of the body; and to say that the liver can secrete both, is as absurd as to assert that there is no necessary connexion between the quality of a fluid, and the structure of an organ which determines the nature of it.

2dly, It is allowed by the first authorities in physiology, that the umbilical vein carries to the fœtus arterial blood: the silence of Dr. Lee on this point, and the importance which he attaches to the blood circulating in the liver, lead one to infer that he entertains the same opinion. If the blood received from the uterus is arterial, what occasion is there for its being converted into albumen, in order to nourish the fœtus? It might just as reasonably be supposed that the arterial blood of the adult, produced by digestion and oxygenation, cannot contribute to the nutrition of the body until it has been converted into albumen. If arterial blood, possessed of its ordinary properties, be communicated to the fœtus, it requires no further change to render it fit for the purposes of nutrition; if it be venous blood which is received, we have no evidence at all, that the system ever is or can be supported by it, and still less that an organ furnished with it can secrete albumen. As albumen exists in the blood, it would appear, if the ideas of Dr. Lee were correct, that nature is not very consistent in her operations, while she, at one moment, draws from the blood nutritious properties, and, at another, absorbs them to convey them into the same fluid.

3dly, If the liver secrete albumen, its presence, it may be further observed, ought to be indicated by the same general appearances that prove the secretion of bile; of the existence of the latter we have the strongest evidence. The gall-bladder and ducts contain, at all times, a considerable quantity of it; but, during fœtal existence, the gall-bladder is so far from being filled with albumen, or exhibiting the least appearance of it, that it contains bile; and instead of the hepatic and common ducts manifesting unequivocal traces of it, "in general," Dr. Lee says, "the hepatic and common ducts of the liver have been found empty, or have contained too minute a quantity of fluid to be collected for chemical investigation; but in the two instances above mentioned, it existed in unusual abundance, and was pressed out upon a plate of glass without mixing with the bile of the gall-bladder." Dr. LEE examined above twenty fœtuses, *and yet, in two only, found a sufficient quantity to be pressed out upon a piece of glass!*

4thly, If the liver be an organ which secretes albumen for the support of the fœtus, how, I would further ask, is its nutrition to be explained in those cases of malconformation, in which the organ is entirely wanting? Many instances of this kind are on record. Mr. BRODIE relates a case, in which no liver could be found;* others are mentioned by M. MERY,† Dr. LE CAT,‡ and Dr. CLARK.§

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* Lond. Phil. Trans., Part I., 1809.

† Histoire de l'Academie Royale des Sciences, 1720.

‡ Ibid, 1740.

§ Lond. Phil. Trans., 1793.

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CHAP. IV.

THE FUNCTION OF THE PLACENTA.

It is not my intention, in this place, to discuss at length the nature of the connexion existing between the mother and fœtus. The experiments which I have performed to ascertain this point, will be given in an Appendix. From the way in which I have conducted my investigations in this physiological inquiry, it is quite clear, whether the connexion between the uterine and umbilical vessels be regarded as *direct* or *indirect*, that the correctness of the principles proposed to explain fœtal nutrition, is not involved in the determination of this question.* Whatever opinion be adopted, the

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* By the term *direct* is to be understood that the uterine terminate in the umbilical vessels; by *indirect*, that the blood, which is returned from the fœtus to the placenta, or transmitted to it from the uterus, does not flow to and from this organ by means of continuous vessels. The following passage from ADELON presents a concise and excellent view of the various opinions entertained on this subject:—

"Mais il se preésente ici deux questions: de quelle nature est la communication de l'utérus avec le placenta? et quelle matière nutritive le premier de ces organes fournit-il au second?

"Relativement à la première de ces questions, plusieurs physiologistes anciens ont cru à une communication directe entre les vaisseaux truth of the subjoined conclusions can scarcely be doubted :—

de l'utérus et ceux du placenta, et par conséquent ont dit que la circulation du fœtus était une continuation de celle de la mère. Leurs arguments étaient : 1° qu'après l'accouchement, il se fait toujours un écoulement de sang plus ou moins abondant par la vulve ; 2° que souvent alors, le sang continue de couler indéfiniment par le cordon ; 3° que dans des femmes enceintes, mortes d'hémorrhagie, on a trouvé le fœtus tout-à-fait exsangue ; 4° qu'on a injecté également les vaisseaux du fœtus par ceux de l'uterus, et les vaisseau de l'uterus par ceux du fœtus ; 5° enfin, qu'on a vu vivre et se développer des fœtus qui n'avaient pas de cœur, et chez lesquels conséquemment la circulation n'avait pu se faire que par l'influence du cœur de la mère. Outre qu'il n'est aucun de ces arguments qu'on ne puisse réfuter, il en est d'autres plus puissants qui prouvent invinciblement que la communication entre le placenta et l'uterus n'est pas directe. 1° L'hemorrhagie, qui se fait par l'uterus et le cordon après l'accouchement, prouve bien la communication des vaisseaux de la mere avec le placenta, mais non que cette communication soit directe. 2° Il est faux que quand la mère meurt d'hémorrhagie, on trouve le fœtus exsangue ; le plus souvent le contraire a lieu, et *Wrisberg* l'a constaté par des expériences directes. 3° Les injections dont on arguë, répétées par les anatomistes de nos jours, ont présenté des résultats opposés, et par conséquent ont conduit à une conclusion contraire. Si, par exemple, on injecte les artères utérines, la matière pénètre dans les veines du même nom, après s'être épanchée dans les lobes du placenta, mais sans jamais parvenir dans les vaisseaux ombilicaux du placenta. Il en est de même, si on injecte les veines utérines ; et, en ce cas, l'épanchement dans le parenchyme du placenta uterin est plus abondant. Si, au contraire, on injecte les artères ou la veine ombilicale, la matière passe des uns de ces vaisseaux dans les autres, s'epanche dans le parenchyme du placenta, mais ne pénètre pas dans les vaisseaux utérins. A la vérité, une ou deux fois, *Chaussier* avec du mercure, *Béclard* avec de la matière grasse, ont injecté par la veine ombilicale, non-seulement toute la masse du placenta, mais encore le tissu de l'utérus et les veines utérines : mais ces anatomistes

1st, The fœtus derives its blood exclusively from the mother.

2dly, The placenta is an organ incapable of producing chemical changes in the blood.

opéraient sur des femmes mortes pendant leur grossesse ; on sait qu'alors les orifices des veines utérines à la surface de cet organe sont béants et fort gros ; et il est possible de concevoir comment la matière injectée, en venant sourdre à la surface du placenta, a pu pénétrer dans ces vaisseaux. En décrivant le placenta, nous avons annoncé la non-communication directe de ses vaisseaux utérines et ombilicaux. 4° La persistance de la vie, et la continuation du développement dans les fœtus sans cœur, ne prouvent rien ; car la contraction des vaisseaux aura suffi pour la circulation. 5° Enfin, voici des faits positifs qui prouvent que la communication n'est pas directe. Il n'y a nul isochronisme entre le pouls du fœtus et celui de la mère ; M. *de Kergaradec*, en appliquant le stethoscope à l'abdomen d'une femme enceinte, est parvenu à distinguer les battements du cœur du fœtus, et ces battements étaient plus nombreux du double que ceux du cœur de la mère. On a des exemples de fœtus qui sont nés, l'œuf étant resté intact, ses membranes externes n'ayant pas été déchirées ; et bien que le fœtus fut alors privé de respiration, cependant sa circulation a continué pendant neuf minutes, dit *Wrisberg*, pendant un quart-d'heure, dit *Osiander*. Enfin, dans des cas où un enfant naissant avait peine à respirer et était en danger de périr, on a entretenu la vie du placenta, en le tenant dans de l'eau chaude à trente-deux degrés, et par suite on a fait continuer la circulation du sang. Il est donc certain que l'uterus et le placenta, quoique en communication à leur point de contact, forment deux organismes séparés ; il se fait là une double perspiration et une double absorption ; c'est-a-dire que l'utérus perspire, à sa surface ou dans le parenchyme du placenta utérin, une matière que les vaisseaux ombilicaux du placenta fœtal absorbent ; et que semblablement les arteres ombilicales du placenta fœtal perspirent une matière qu'absorbent les veines utérines du placenta utérin."—Physiologie de l'homme, Vol. IV., p. 394.

3dly, The fœtus has not in activity any organs that can in the least oxygenate the blood it receives.

4thly, Venous blood cannot support organic life.

Dr. WILLIAMS, of Liverpool, a talented physiologist, infers, from experiments which he has performed to ascertain the exact relations between the uterus and the fœtus, that the connexion between them is formed by means of inosculating vessels, and consequently is *direct;* but I am disposed to think, if this were the nature of the union, that the wisdom manifested in the construction of the placenta would be less evident than will appear from the following views.

The arguments which HARVEY advances, founded on anatomical facts, are unfavourable to a direct connexion :—“ FABRICIUS,” he says, “agens de unione carnosæ hujus substantiæ cum utero, pluribus quidem rationibus (sed invalidis) contendit, vasa umbilicalia, cum uterinis, plurimis osculis conjungi ; idque potissimùm ab eo factum est, ut antiquum dogma ab omnibus ferè receptum tueretur : fatetur enim se nihil certi super hac re affirmare posse, *quòd carnea moles rem ipsam perspicere ac judicare*

vetet. Veruntamen nec ratio, neque sensus suadent; dari magìs anastomoses in utero, quàm in hepate, inter ramos Portæ, et cavæ; aut in mammis, inter vasa, quæ sanguinem, et ea quæ lac deferunt. Est quidem alicubi vasorum juxtapositio contigua, et interdum unius in alterius tunicam ingressus; nuspiam autem perfectus coalitus sive unio, qualem FABRICIUS imaginatur. Aliter enim si foret, deberent et venæ pariter cum arteriis conjungi: vasa enim, sanguinem a matre in uterum et carunculas deferentia, sunt arteriæ; quæ autem ab utero in fœtum remeant, venæ sunt, utì omnibus palàm est; sanguinem enim deducunt e placenta in venam cavam.

"Verior itaque mihi videtur Arantii sententia; oscula nempe venarum umbilicalium, cum vasorum uteri orificiis minimè conjungi. Minor enim numerus est vasorum deferentium ad uterum, quàm venarum regerentium ad fœtum; plurimæque harum propagines in Chorio terminantur. FABRICIUS tamen Veterum sententiam, vel eorum reverentiâ ductus, vel erga Arantium invidiâ, mordicus defendere nimisquam satagit."*

M. M. PREVOST and DUMAS, celebrated

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* De uteri membranis et humoribus.

for their microscopical observations, maintain that the red globules in the blood of the fœtus differ in form and volume from those of the adult. If the difference were unequivocally proved, it would considerably modify our ideas concerning the functions of the placenta and the kind of connexion existing between the uterine and umbilical vessels. However high an opinion we may entertain of the candour and talents of those engaged in microscopical investigations, it cannot be considered disingenuous to doubt the correctness of results furnished by such means, since there is scarcely an object that has been examined by the microscope, although many times larger than a globule of blood, which has not been variously described by different persons.

If we advert, for example, to the opinions which have been formed concerning the size and appearance of globules of blood, there is the greatest discrepancy. "They have been compared to a globe, to a bladder with a pea in it, to a piece of money, to a drum, to a candlestick, to a hexædron, and I know not what else. The globules are the staple commodity, the *feræ naturæ* of physiological advertisers."*

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*Notes to MAGENDIE'S Physiol., by MILLIGAN, p. 574, Ed. 2d.

According to the opinion of Dr. Young, a globule is $\frac{1}{6060}$th of an inch in diameter; of Bauer, $\frac{1}{1700}$th; of Prevost and Dumas $\frac{1}{3810}$th. When the attention of physiologists was generally directed to the examination of the *animalculæ* in the semen, each observer was continually discovering something new and extraordinary. One could distinctly perceive the *animalculæ* marching in a troop wagging their tails; another could distinguish their sexes, and a third clearly saw one break the membranes which enveloped it, and come out a perfect human being!

These observations were made on objects so minute that mankind generally were unable, even with the same magnifying powers, to discern them, much less to give a particular description of their various parts. It has frequently been remarked by those, who suppose the placenta prepares a nutritious kind of food, that the maternal blood is unfit to support and develope the organic powers of the fœtus. They imagine that globules about $\frac{1}{6060}$th of an inch in diameter are much too large to circulate in its delicate system. Similar considerations have led others to conclude, that the red globules in the blood of the fœtus must be much smaller than those belonging to the adult, and, fully convinced of the plausibility of this opinion, physiologists have endeavoured to prove its correctness. PREVOST and DUMAS state, from microscopical examinations, that the red globules in the blood of the fœtus are only half the size of those in the adult. If they had not entertained a preconceived notion that such ought to be the case, why did they make the investigation? Whether they regarded the vascular connexion between the fœtus and the uterus as *direct* or *indirect*, there was no reason whatever to lead them to suppose that there is any difference in the size of the globules in the blood of the fœtus and that of the adult. If the union be considered of the former kind, the blood circulating in the maternal and fœtal systems must be precisely the same; if, of the latter, although this identity may not be equally evident, yet, as the fœtus has no other source than the maternal blood for its support, it is almost impossible to arrive at any other conclusion. If we reflect on the manner in which the globules of blood are formed, we cannot for a moment suppose, that the fœtus or the placenta is capable of producing any change whatever in the form and magnitude of those derived from the mother.

The blood, however compound in its nature, is the production of a digestive and oxygenative process. The chyle, which is regularly created in order to repair the wastes of the system, contains those molecules which are subsequently distinguished as the red globules of blood.* They are colourless, most probably, because they have not as yet been repeatedly exposed to the action of atmospheric air.

It has been satisfactorily proved by physiologists, that the blood, during inflammation, possesses a greater proportion of red globules than in health. It is stated in the "Experimental Inquiry into the Laws of Organic and Animal Life," that the blood, in all inflammatory affections, and under any excitement of the system by exercise and stimulants of every kind, *is better oxygenated from its more frequent circulation in the lungs.* It is, therefore, easy to account for an increase in the number of red globules, under such circumstances, and the explanation is, also, favourable to the opinion, that chyle differs only from blood in the chemical changes which the latter has undergone in the lungs.

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* M. BAUER à Londres et M. M. DUMAS et PREVOST à Genève ayant examinè au microscope le chyle, ont reconnu en lui les mêmes globules que dans le sang, avec la seule difference que ces globules n'etaient pas revetus del 'enveloppe de matière colorante.—ADELON's Physiologie del' Homme, tom. III., p. 39.

The blood in crustaceous animals is *white* — may not this circumstance arise, in part, from a less extensive or complete exposure to the influence of oxygen? The more or less perfect manner in which oxygen is enabled to act, *occasions all the diversities in the colour of the circulating fluid in warm blooded animals at different ages, and also all the varieties in the degrees of animal heat.*

Since the sanguineous fluid is the production of the chylopoietic and pulmonary organs, it is manifest, if we suppose the placenta to be endowed with the power of producing the same effect, that it must possess relations to the fluid it produces, similar to those which the above organs bear to that circulating in the adult; for unless it is capable of performing a digestive and oxygenative process, how can it possibly give rise to new globules of blood? Is there any analogy between the functions of the placenta and those of the chylopoietic viscera and the lungs? There is little reason to suppose the fœtus an active and creative agent, as it does not call into exercise the Primary organs of the system. If instead of possessing organs essential to digest and elaborate food, we received arterial blood from a source external to ourselves, is it probable that its globules would be either augmented or diminished in size? It is scarcely necessary to expose further the apparent inconsistency of attributing to the placenta or the fœtus the power of producing them. In certain cases of monstrosities, almost the whole of the abdominal viscera have been found wanting, and yet, under such circumstances, the rest of the fœtus was well nourished.

VIEUSSENS endeavoured to shew that the uterine arteries anastomose directly with the radicles of the umbilical veins, but it is generally allowed that there are several objections to his mode of investigating the subject. Experiments have also been performed by others, for the purpose of ascertaining the exact relations between these vessels, and opposite conclusions have been almost invariably drawn from them. MONRO, Primus, in repeated injections of the placenta, did not succeed in proving a direct connexion between them; MAGENDIE and many other distinguished physiologists, have been equally unsuccessful.

By carefully observing the structure of organs in connexion with the operations of the animal economy, we are sometimes able to comprehend the particular purposes they serve, or, at least, to make considerable approaches towards a knowledge of them.

The quantity of blood transmitted to the lungs at each contraction of the heart, and its frequent renewal, lead the inquiring mind to infer the office and importance of the pulmonic functions; the magnitude of the nerves belonging to the senses in the different gradations of animal life, and a variety of organic adaptations and actions of the system, give rise to numerous and not unfrequently well founded surmises concerning the ends they promote. In applying the same method of investigating the intentions of nature to the uterus, and its appendages during pregnancy, we shall probably acquire correct notions of their uses. The uterus, for example, is supplied with four arteries, two *spermatic* and two *uterine*. It is scarcely possible to conceive that the office of these vessels is merely to support the vitality of the organ in its unimpregnated state, because, at this time, it is extremely diminutive, and consequently requires only a small portion of blood. *It appears rational to imagine that they are formed principally to convey to the fœtus an arterial fluid.* These vessels are enlarged, and are likewise rendered more active, as the fœtus advances towards maturity. Such changes are what the physiologist would anticipate from a knowledge of the dependence of the fœtus on the maternal system for its support.

Whenever a stimulus is applied to any part of the body its vascularity is considerably augmented. The effect, in the first place, is occasioned by a greater action of the capillary arteries belonging to the affected organ, the tendency of which is to accelerate the flow of blood towards it. It cannot justly be ascribed to any immediate alterations in the veins, except so far as those alterations are considered as effects arising directly from an increased action of the arteries, *because the stimulus which draws the arterial fluid to the surface of the excited organ, tends, at the same time, to propel the venous with greater force in its natural direction towards the heart.**

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* The difference which I am desirous of establishing here between the capillary arteries and veins, is simply in regard to a *priority* of

We know little or nothing concerning the rudiments of the embryo, but we have certainly sufficient ground for the assertion, that vital actions are connected with its earliest development, and may be justly regarded as natural stimulants applied to the surface of the organ to which the embryo is in juxta-position. If a state of vascularity occasions a local or general derangement of the system, it is diseased; but if it produces effects essential to certain important functions of the animal economy, it is to be considered in another light. The embryo, for many days after conception, has no connexion whatever with the uterus; but, after a certain time, its vital energies possess sufficient action to stimulate the internal

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affection on the application of a stimulus. Since arterial blood has a tendency to flow *from* the heart, on account of the propelling power of this organ, and the venous *to* it, from causes which draw it to the chest, is it not reasonable to suppose, that the arteries and veins are very differently situated? If we allow that they are equally excited by the application of a stimulus, have we not sufficient reason to conclude, that their respective fluids will proceed, with accelerated motion, in two opposite directions, *and that, therefore, an increased vascularity in any part arises, primarily, from an augmented action of the arteries;* but that, if these receive more blood than usual, the veins will also circulate it in the same proportion, because it is their office to remove what the former transmit, such removal being necessary to prevent congestion?

surface of this organ, to such a degree, as to lead to the subsequent connexion between them.

It not unfrequently happens, in the inflammation of an organ, that it becomes attached to the parts adjoining it, and a firm adhesion takes place. If the vessels of the inflamed organ did not directly, or indirectly, through the medium of intervening matter, extend themselves to other organs, the almost inseparable connexion between them could not be formed. Pathologists, in their investigations into the nature and progress of disease, have frequent opportunities of demonstrating this fact. That the embryo does not depend on any mysterious adaptations of the uterus, is proved by its growth in cases of *extra-uterine* development. *The causes of its production in the uterus occasion its formation in every unnatural situation.* If the fœtus is connected with the parietes of the intestines, which it sometimes happens to be, it continues to grow, until the general derangement it occasions in the maternal system, destroys its own being, or that of the mother. It has formed an adhesion to these parts, from the stimulus imparted to their vessels, by the manner in which it acts on those of the internal surface of the uterus. The principal difference between this organ, and the different viscera, to which it is sometimes attached, is in the quantity of blood furnished for its nutrition. When the fœtus is *extra-uterine,* it is sometimes capable of existing only a short time, because it does not receive blood adequate to its necessities. The small arteries belonging to the intestines are large enough to maintain their vitality and functions; but when a small portion only of their surface is occupied by a placenta, an abundant supply of arterial blood cannot be afforded to the fœtus. During pregnancy, the uterus becomes more vascular than any other part of the system under similar circumstances, *and it is, therefore, well adapted to nourish the fœtus in every stage of its progress.* I cannot conceive any other mode of explaining, in a satisfactory way, the manner in which a connexion is formed between the embryo and uterus, or any other part of the system. The blood of the mother must necessarily pass from the uterine vessels to the placenta, which it could not regularly do, unless the relations between the two organs were such as I have described.

The explanation which I have here given, is materially strengthened by the fact related in the following passage from MAGENDIE:—"In bitches, about the middle of their gestation, there are seen a great number of small arteries, which, issuing from the tissue of the uterus, pass into the placenta, where they are divided into several ramifications. *At this period, it is impossible to separate these two organs, without tearing these arteries, and producing a considerable hemorrhage.*[*]

In Dr. THOMPSON'S admirable work on inflammation, many experiments are related which illustrate the speedy formation of vessels from an elongation of those already existing. An argument founded on analogy, derived from the efforts of nature in disease, is not precisely applicable to what occurs in the union of the placenta and uterus. When an organ is highly inflamed it generally occasions a deposition of lymph, which, if not ultimately absorbed, becomes organized, and a firm adhesion is formed between it and contiguous organs; but in the connexion of the uterus and placenta, elongated vessels have not, as in inflammation, previously undergone such extensive changes as to pour out any thing that easily leads to the formation of an unnatural union. A connexion is, indeed, formed, but one of a peculiar nature. The uterus does not become disorganized from its various modifications during gestation, nor the organ to which it is attached, *but on the contrary, blood continues to flow indirectly, from the mother to the fœtus, and in the same way from the fœtus to the mother, without any interruption to its circulation.* These peculiar circumstances can scarcely be supposed to exist in diseases: "The liquors," as MONRO, Primus, justly observes, "are not carried from the mother to the fœtus, or from the fœtus to the mother by continued canals, that is, the uterine arteries and veins of the secundines;* but the extremities of the umbilical vein take up the liquor by absorption, in the same way as the lacteals do in the guts; and the umbilical arteries pour their liquors into large cavities of the sinuses or other cavities analogous to them."

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[*] MAGENDIE'S Physiology, trans. by Dr. MILLIGAN, p. 503, Edit. 2.

If this view be correct, we cannot but observe the wisdom which nature has shown in the construction of the placenta.—If we suppose the connexion between the mother and placenta to be maintained by fifty, or any number of vessels—a mode of union which is conceived to exist by several distinguished physiologists—it will necessarily follow, *that whenever physical or moral causes disturb the general circulation of the mother, that of the fœtus will be disordered to an equal extent, and consequently its existence rendered extremely precarious.*

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* HARVEY, de Generat. Exercit. 70. RUYSCH Thes. 5 n. n. 41.

It is well known that the maternal system is frequently subject to severe and sudden disturbances. If we imagine a continuous stream of blood flowing from the mother to the fœtus, it is evident that the latter would be affected in proportion to the excitement or depression of the circulatory system of the former: and if such were really the nature of the connexion between them, I cannot conceive how the life of the fœtus could be preserved when the maternal system is particularly disturbed. But, if the placenta be regarded as an organ intervening between the mother and the fœtus, for the purpose of receiving the blood of both, it is not difficult to understand how a temporary derangement of the maternal circulation seldom materially affects that of the fœtus. *The placenta is therefore a barrier to the trans-*

mission of injurious effects, arising from sudden and violent emotions of mind, or from a variety of other causes that render irregular the general circulation of blood.

This opinion derives support from the circumstance that the placenta adheres sooner to the human womb, than to the uterus of other creatures, and the fœtus has a larger proportional placenta, whereby its adhesion is stronger.* The human frame is more liable to be greatly excited and depressed by various passions, medicines, and diseases, than that of the inferior animals, and would consequently seem to require during pregnancy, that the placenta should be larger, and adhere at an earlier period to the uterus in order to secure it from frequent accidents.

But although human beings are more exposed than the lower animals to severe disorders of the circulatory system, we must not imagine that the latter are wholly exempt from disorders. Many of them from being subject to man, or being made the objects of his sport, are frequently exposed to treatment and circumstances calculated to derange the free and regular circulation of the blood; and some possess placentæ, whose size and organization are apparently designed to protect the system from injury. It does not appear very probable, that the uterus pours venous blood into the placenta. It has been stated above, that if the uterus become more vascular than usual, from the vital actions of the embryo, which stimulate it, there cannot be any tendency in the veins to discharge blood, but a contrary tendency to return it in its natural course to the heart of the mother; whereas, if the arteries are excited, the arterial blood will necessarily be directed to the uterus, *since a propelling and not a withdrawing power is operating from behind.* The circumstances of the uterus, during gestation, differ widely from those of the intestines when they are the seat of hemorrhage,—a disease which may be alluded to in disproof of the reasons assigned to explain the flow of arterial, rather than venous blood, into the uterus: in this disease, the constitution generally labours under great debility, conjoined with local derangement, which produces an obstruction of the circulation; the veins of the abdomen are, consequently, congested, as well as weakened. When the surface of an organ is stimulated, a greater proportion of blood is immediately determined to its capillary arteries, and their increased action is rather of a continued than momentary nature; hence, it is evident, that the state of the uterus is very dissimilar from that of the veins when they pour out venous blood. *The causes which regulate the flow of blood from the uterus to the placenta, are of the same kind as those which promote its circulation from the fœtus to this organ.* In both cases a propelling power is exerted from behind. In the former the maternal, in the latter the fœtal heart transmits it to the placenta.

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* MONRO, Primus, Edinburgh Medical Essays, Vol. II, p. 338.

The venous blood transmitted by the fœtus to the placenta, is absorbed by veins and conveyed to the lungs of the mother; the arterial blood derived from the uterus, is absorbed by the umbilical vein, and flows to the heart of the fœtus. We are not capable of forming an accurate idea of the number or nature of those powers which cause, in either case, the return of blood to the heart. It is quite clear, however, that it flows to the placenta from two opposite points, and that it is absorbed and carried to the mother and fœtus in a similar way, although not precisely the same, in both instances. The views of BARRY go far towards explaining the circulation of venous blood in viviparous animals after birth, but do not account for its circulation in the fœtus.

It was stated by VIEUSSENS that the red globules of blood were not absorbed by the umbilical vein. The same absurd doctrine was also taught by MONRO, Primus. "The fœtuses of viviparous animals," observes the latter, "have their red blood from the same source that chickens in eggs have theirs, *the action of the heart and the vessels in their body and secundines.*"*

If oxygen, and that organic construction universally belonging to the respiratory organs of animal and vegetable life be wanting, the process of oxygenation cannot possibly proceed. The simple action of muscles, or vessels, on the particles of blood, cannot create an arterial fluid.

I have already alluded to the impossibility of the placenta performing the office of lungs. If a connexion between the placenta and uterus either of a *direct* or *indirect* kind be denied, it is impossible to account for the origin of fœtal blood. The fœtus possesses not the organs necessary to produce it, and, therefore, it must necessarily pass from the uterus to the placenta. The discrepant opinions, as to the manner in which the blood circulates to and from these organs, do not render less valid the views proposed to explain fœtal nutrition. "That the blood," observes Dr. Bostock, "which is sent from the fœtus along the umbilical cord to the placenta in the venous state is returned in the arterial state, so that we are justified in concluding, *that this organ supplies the place of the lungs, or produces the chemical changes in the blood which fit it for the support of life.* It is no doubt difficult to conceive how this can be accomplished without a *direct* vascular communication, and we can only account for it by supposing that the minute vessels of the placenta, like those of the lungs, are capable of absorbing and exhaling through their coats, the substances necessary for effecting the change, the arteries of the maternal placenta exhaling oxygen and absorbing carbon, while those of the fœtal placenta perform the reverse operation."*

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* Edinburgh Medical Essays, Vol. II. p. 301.

The same views are apparently entertained by Mr. Brodie. In speaking of a fœtus he dissected, in which the circulation had been carried on without a heart, "it appears extraordinary," he says "that under these circumstances, notwithstanding the circulation through the placenta must have been more languid than is natural, that that organ should nevertheless, have been capable of exercising its proper functions, so as to produce those changes in the blood, which are necessary for the maintenance of fœtal life. This may be explained by considering that in the natural fœtus the umbilical arteries are branches of the general arterial system, and only a portion of the blood of the child is sent to the placenta, whereas in the fœtus, which I have described, the trunk of the vena cava was continued into the vein of the chord, and the whole of the venous blood circulated through the placenta, and was exposed to the influence of the arterial blood of the mother."*

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* Bostock's Elementary System of Physiology, Vol. II. p. 301.

Does not the fœtus require something more nutritious than oxygen for its support or than venous blood combined with it? If blood is either *directly* or *indirectly* derived from the uterus, would not the preceding observations lead us to conclude that it is arterial; if it be, what necessity is there for forming fanciful hypotheses to account for the nutrition of the fœtus?

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* Phil. Trans. Part I., 1809.

The mode in which I have endeavoured to account for the placenta becoming connected with the uterus, is not rendered less probable by investigations into the subject of parturition. The facility with which the placenta is detached from the uterus, may seem an insuperable objection to the union, previously described as existing between the uterine vessels and the placenta. The maternal placenta continues to receive blood as long as it is able to transmit it to the fœtus; but the removal of the former organ necessarily arrests the circulation of this fluid flowing from the placenta along the umbilical vein, *and consequently the placenta is considerably congested.*

It is congested because it has no means whatever of transmitting, as usual, the blood it receives, and its engorgement continues to increase until it is expelled: it is indeed this circumstance which weakens its adhesion to the uterus. When the connexion between the fœtus and the placenta is broken, the umbilical vein cannot, as usual, carry blood from the latter, and, therefore, those intimate relations which exist during gestation between the placenta and the uterus, arising from an undisturbed circulation, are destroyed: the placenta is consequently rendered a lifeless mass.

After the expulsion of the fœtus, pains commence, accompanied by strong contractions of the uterus, the influence of which is exerted upon the placenta; and while the uterus is powerfully acting upon it, it is also diminishing the capacity of the uterine arteries. *By the latter effect, it is lessening the vascular connexion between the two organs and the liability of the occurrence of hemorrhage; by the former, it facilitates the expulsion of the placenta.* These assertions are susceptible of mathematical demonstration. If we suppose the surface of the pregnant uterus, immediately before delivery, to be represented by 50, the contractions it undergoes during the after pains, may probably diminish it to 15, or even less, and consequently the vessels which unite the placenta and uterus, will have their capacity lessened in the same proportion. This important change in the extent of the uterine surface *affects the arteries almost as much as if a ligature were tied on each.* Hemorrhage very frequently succeeds the expulsion of the placenta, and this arises from the imperfect contractions of the uterus; in consequence of which, the mouths of the arteries are left partially open. This explanation removes any objection to the possibility of separating organs so intimately united as the uterus and placenta. There are three provisions for the expulsion of the placenta, and the prevention of hemorrhage :—

1. The engorgement of the placenta, the first preparatory step.

2. The strong contractions of the uterus exerted upon the placenta.

3. The contractions of the uterus which diminish the capacity of the uterine arteries, and thus directly lessen the connexion of the placenta with the uterus, and also prevent the occurrence of hemorrhage.

"If the vessels of the secundines," observes MONRO, Primus, "were joined by an anastomasis to the uterine, an hemorrhage, or flux of some liquors, would happen at the umbilical vein whenever the naval string was broke or cut, and would continue as long as the after birth adhered to the uterus ; and if the umbilical vessels were tied, the circulation would still continue in the placenta, and it would not become a lifeless mass."*

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* MONRO, Primus, Edinburgh Medical Essays, Vol. II, p. 295.

But it is evident, from what has been stated, that it is scarcely possible for great hemorrhage to occur on the separation of the umbilical cord, *because the circulation of blood in the umbilical vein does not depend on the presence of the placenta only, but also on that of the fœtus.*

The last mentioned author still further remarks, that the placenta, becoming a lifeless mass, after the separation of the cord, "shows the secundines to owe their life and action to the fœtus." *The secundines are indebted not only to the fœtus for their life and action, but also, and in an equal degree, to the mother. They receive and transmit blood to both, and therefore it is unphilosophical to attribute their existence exclusively to either.*

It is well known that "the placenta separates much more easily after the child is born than while it is yet contained in the uterus." This circumstance is certainly in favour of the preceding observations in regard to the manner in which the placenta is supposed, in the first place, to have its connexion with the uterus weakened. As long as the blood continues to flow to and from the placenta without intermission or irregularity, it is extremely difficult, if not impossible, to break its attachments. The circulation of the blood between these organs serves to maintain that vascular union which conjoins them. It has already been observed, that the placenta occasionally protects the fœtus from the injurious influence of violent emotions; but, nevertheless, it sometimes happens, that this influence is communicated to the uterus, and abortion is the consequence. Causes which accelerate this effect, disturb, *primarily*, the circulatory system of the mother, and *secondarily*, that of the fœtus; if, to such an extent, as to destroy the action of the fœtal heart, the blood no longer flows from the placenta to the fœtus. In this case, the placenta becomes congested, because it cannot, relieve itself, as usual, of the blood it receives.

Various views have been proposed, to explain the occurrence of parturition at regular periods, in the same species of animals, but no satisfactory reason has, as yet, been assigned.

Sir E. HOME is of opinion, that "the lungs are the last part of the embryo which are completely formed. As soon as this happens, the blood that circulates through the lungs must greatly diminish the supply of blood to the placenta; the consequence of which will be, that the small terminal arteries of the fœtal portion will become contracted, which cannot happen to any great extent, without producing more or less of a separation of the placenta and chorion, and this will be followed by the expulsion of the young. That very slight disturbance, at this period, brings on labour, is well known, from the number of children prematurely born, that are with difficulty kept alive, till the circulation through the lungs becomes complete."

The ideas of Sir E. HOME, concerning the nutrition of the fœtus, to which I have already alluded, have evidently given rise to this very fanciful hypothesis. In supposing the lungs of the fœtus, at the latter part of utero-gestation, to withdraw a small proportion of blood from the placenta, it is manifest *that he regards the fœtus as possessed of a determinate quantity of blood; so that, if one part of the fœtal system receives a little more than usual for its further development, another will necessarily receive less.*

The fœtus has, at least, ten times the quantity of blood at the seventh, that it has at the second, month of pregnancy; and, as the increase cannot possibly be derived from the fœtus, how can the more complete formation of the lungs affect the connexion between the uterus and the placenta?

The organization of the lungs is not perfected, except at the expense of sanguineous fluid. If it were even admitted, that the lungs withdraw a certain quantity of blood, is it not manifest, that this would be proportionate to the gradual development of these organs, whilst every other part of the fœtus would, at the same time, be improved to a similar extent? As it is impossible to deny this fact, there is not the smallest degree of evidence, or the slightest shade of probability, that an alteration in the structure of the lungs can produce any effect whatever on the proportion of blood circulating in the fœtus. To say that the additional quantity of blood, required by the lungs, disturbs the circulation of the placenta, is no less absurd, than it would be to assert, that it disorders the circulatory system of the mother, as this supplies the gradually increasing demands of the fœtus. If the fœtus suddenly respired, and produced by this act the same considerable changes in the capacity of the chest, and the distribution of the blood, that it does immediately after birth, there would be then something like probability in supposing that the greater action of one part of its system diverted the course of the blood from the placenta. I shall not presume to offer any opinion on the cause of parturition. It is the duty of the philosophical inquirer to expose the fallacy of erroneous theories and incorrect hypotheses, although he is unable to propose others entirely satisfactory, since such exposure clears the way for subsequent investigations and discoveries.

CHAP. V.

TEMPERATURE OF THE FŒTUS.

THERE are certain points connected with the consideration of the present subject, that have not as yet been fully explained, and which are intimately related to the views already proposed, concerning the nutrition of the fœtus. It has been proved by experiment, that the temperature of the fœtus is seldom above 92° or 95°F. *It is said to be higher when the fœtus lies dead in the uterus.* "If this fact is correct," observes MAGENDIE, "the fœtus must possess some means of lessening the temperature that does not exist after birth."* If according to the principles previously stated, we regard the fœtus as receiving arterial blood from the mother, we shall find few difficulties in attempting to render these phenomena more intelligible. It is satisfactorily ascertained that the sanguineous fluid loses a portion of its animal heat, as it recedes from the centre of circulation. The fœtus is supplied with blood from the spermatic and uterine arteries, and as this fluid in its passage to the placenta is considerably removed from the source of its oxygenation, it is reasonable to imagine that its temperature is slightly diminished, when it reaches this organ.

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* MAGENDIE's Physiology, trans. by Dr. MILLIGAN, p. 511.

It will indeed scarcely be denied, that such a change is likely to be produced, when it is absorbed and conveyed to the fœtus, which possesses no means of generating animal heat. Although the fœtus is incapable of contributing to its own support, by renewing the vital qualities of the blood, yet, as the process of assimilation is active, and as the excretory functions of the skin are carried on in a modified degree, those causes are in operation which must tend to diminish the temperature of blood circulating in the fœtus. There is undoubtedly *a great difference in the state of the sanguineous fluid in one body, in which it is continually renewing its heat, and in another, in which no similar change takes place.*

There is another reason, which, in conjunction with the above, seems sufficient to account for the low temperature of the fœtus. The whole of the adult blood passes once, every two or three minutes through the lungs, and is, consequently, completely acted upon by atmospheric air, but when the foramen ovale continues open after birth, the temperature is several degrees less than natural. This difference arises evidently from the imperfect oxygenation of blood. The whole blood of the fœtus is not exactly renewed in the same time as that of the adult, and on this account, the temperature of the fœtus will be less. The arterial blood conveyed to the vena porta and the vena cava inferior, is mixed with the venous blood of the vena cava superior in the right auricle of the heart, and, therefore, the arterial blood of the fœtus is not so purely arterial as that of the adult. It is not difficult to explain why the temperature of a dead fœtus is higher than that of a living one. In the former, none of those functions are in action which diminish the heat of the blood, as circulation, assimilation, and excretion from the skin, all of which exist in the latter.

If the dead fœtus be regarded as a mass of inorganic matter, the degree of its temperature will illustrate a common law in physics, *that heat has a tendency to diffuse itself through contiguous bodies until an equality of temperature is established.* The warmest give out, and the coolest receive, until they have attained a uniform degree of heat. It is, therefore, manifest that as long as the dead fœtus remains in the uterus it will be of the same temperature as the mother. If this explanation is considered satisfactory, it is obvious that the conclusion of MAGENDIE is fallacious, viz. that "the fœtus must possess some means of lessening the temperature that does not exist after birth."

CHAP. VI.

THE ORIGIN OF THE LIQUOR AMNII AND MECONIUM.

It has been repeatedly stated in this work, that wherever vital actions exist, different excretions are invariably produced. It has also been observed, that the modifications which the sap undergoes in the leaves, in summer, are accompanied by an ejection of matter, in quantity proportionate to the extent and energy of those operations which occasion them; and still further, that the laws which I have attempted to develope and establish, in regard to the nutrition of the vegetable, do not differ materially from those which regulate the same process in the animal. A knowledge of this general agreement is extremely valuable, as it enables us to explain a variety of phenomena that have hitherto been deemed inexplicable, or have been accounted for on erroneous principles. The rapid growth of the fœtus shows that the powers of nutrition are active, and as it is constantly supplied with arterial blood, the cause of all organic actions, it necessarily follows, *that transpiration, which is simply an effect of them, will take place from the whole surface of the body.* This result is as inevitable, as that its obstruction, by artificial means, never fails immediately to produce great oppression of the vital powers, and subsequently death. The temperature of the body is regulated by transpiration, or by what is called *sensible* and *insensible* perspiration. It has long been a subject of discussion, whether the matter formed by *sensible* or *insensible* perspiration be the same, or essentially different. HALLER was of the latter opinion.* I cannot conceive there is any difference, except in the state in which it exists.†

The insensible perspiration, or transpiration by evaporation, under the unexcited state of the body, maintains the proper temperature of the system, and allows the removal of what is unessential. We always observe, when the heat of the body, in health, is increased by great muscular exertion, and by internal stimulants, that the *insensible* is converted into *sensible* perspiration. The augmented activity of the cutaneous function is occasioned by the greater energy of the pulmonary and circulalatory systems.

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* See BOSTOCK'S Physiology, Vol. II., p. 235.

† Dr. BOSTOCK, in speaking of the distinction which Dr. EDWARDS has made between evaporation and transpiration, observes—"that in both cases the matter to be transpired must leave the mouths of the vessels in a fluid form, and that the fluid is subsequently evaporated by means of the air, so that, except in degree, I do not perceive any essential difference between the operations."—Elementary System of Physiology, Vol. II., p. 237.

The subsequent views and reasoning are not in the least affected by our inability to determine the correctness of either of these opinions. Evaporation necessarily implies the presence of air, and, therefore, it is quite evident, that it cannot exist in the fœtus immersed in the amnios; yet *transudation,* which relieves the system in a similar manner, is obviously unimpeded by the same circumstances. The experimental inquiries of Dr. EDWARDS into the subject of transpiration, are highly satisfactory and valuable. " Supposons," he says, " que l'eau, en contact avec la peau, n'ait aucune action physiologique sur cet organ. En ce cas, elle se bornerait à empêcher le contact de l'air, et, par conséquent à supprimer la transpiration par évaporation à la peau. *Il resterait la perte par transsudation à la peau,* qu' il faudrait ajouter à celle qui se fait par les poumons."*

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* Del' Influence des Agens Physiques, p. 344.

No part of animal or vegetable nature could exist, unless it were able to remove its excrementitious matter, and as its expulsion invariably accompanies vital actions of every description, is it not more than probable, from simple reasoning, that transudation necessarily takes place in the fœtus? This operation indeed, or one analogous to it, must be performed. *Whatever breathes or vegetates is continually performing certain excretory actions.* If, therefore, the fœtus exercises the function of transudation, what probable source is there, except the skin, to account for the secretion of the amnios?

Magendie, in allusion to this subject, makes the following observations:—"Exhalations seem to take place in the fetus, for all its surfaces are lubricated nearly in the same manner as afterwards; fat is in abundance; the humours of the eye exist; cutaneous transpiration very probably takes place also, and mixes continually with the liquor amnii. With regard to this last liquor, it is difficult to say whence it derives its origin; *and though no sanguiferous vessels appear to be directed* to the amnios, it is nevertheless probable that this membrane is its secretory organ."*

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* Magendie's Phys., trans. by Dr. Milligan, p. 511, Edit. II.

It is not easy to conceive how so acute and distinguished a physiologist as MAGENDIE, in considering the secretion of the amnios, could almost entirely overlook the function of the skin. It not unfrequently happens when we examine any scientific subject in a superficial or general manner, that we fail to give a correct or satisfactory account of very ordinary, and sometimes very obvious effects. If a fluid similar to the amniotic had always been found in the chest of the fœtus, its production might have been plausibly ascribed to the pleura, it could not have been referred to any other membrane; but, in endeavouring to explain the origin of the amnios, we have hitherto neglected to take into consideration *the influence of a function, which is ascertained to exist, and have attached undue importance to a thin, pellucid, and exsanguineous membrane, the secretory power of which, in this situation, is not ascertained in any degree.*

It has been already stated, that the quantity of excrementitious matter evolved from the animal or vegetable, is always proportionate to the energy of its vital actions. Serous membranes, in the state of health, secrete only what is necessary to lubricate their surface; but when they are highly stimulated by inflammation, or disordered by other causes, they pour out an abundance of serous fluid, exhibiting, in this case, the very close relations existing between the degree of vigour possessed by an organ, and the quantity of its peculiar secretion.

If we allow that the amnion secretes, the activity of its function will be admitted to be proportionate to its vital energies; but this activity cannot rationally be supposed to equal that of the well-known powers of the skin, which are engaged, in every period of life, in removing from the surface of the body, perspirable matter. The physiologist may very safely infer, that the amnios is secreted by the skin, from the fact, *that such secretion is its natural and unceasing function, and is, moreover, a necessary consequence of its organization, and the distribution of blood to it.* That it is secreted by the amnion, is very improbable. If the fœtus had been placed in a medium of a temperature much lower than its own, *transudation* from the surface of its body would have been almost wholly prevented; but, as the fluid, in which it is immersed, is of the same temperature as itself, such an effect is rather facilitated than impeded.

“Deux causes,” observes Edwards, “influent principalement sur ces deux fonctions: (absorption and transudation) la quantité de liquide contenue dans le corps, et la température del' eau dans lequel il séjourne. Plus il y a de plénitude, moins il y aura d' absorption; plus la température del' eau est basse, moins il y aura d' exsudation. Dans la limite extrême de 30° cent. le contraire a lieu; les pertes l'emportent de beaucoup sur les gains, parceque la transsudation prédomine sur l'absorption."*

The liquor amnii augments with the development of the fœtus. If this fluid is exuded from the skin, its gradual increase is in perfect accordance with those principles which are supposed to explain its origin. *The vital actions of the fœtus, and a more extended surface for secretion, augment in proportion to the progress of gestation.*

"In his Comparative Anatomy, page 70, the late Dr. Monro observes, that the liquor amnii, at first, is in a small quantity, afterwards increases for some months, then again decreases; and in a cow, near her time, the quantity of this liquor is not above a pound. This assertion is directly contrary to what the author has advanced, and to what every one conversant with the management of cows well knows, viz., that so abundant is this liquor, at the time of calving, that not less than two or three pails full come away in the whole: I have been led, therefore, from very accurate observations, to state the quantity of this liquor, bears always a proportion to the size of the fœtus, and is in the greatest quantity, instead of being least, in the latter months."*

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* Del' Influence des Agens Physiques, p. 352.

In the human race, the amnios is found to increase with the growth of the fœtus. The quantity of water discharged at the termination of pregnancy, leads us to infer that such is the case. The great quantity of it in the womb is evident, when it is expelled a day or two before delivery, in consequence of which the abdomen is considerably diminished in bulk. The secretory function of the skin in the fœtus cannot be nearly so energetic as in the child or adult: since its system is not continually excited by muscular exertion, and the chylopoietic viscera do not perform, as after birth, their varied and essential offices: its animal heat, too, is comparatively low, and its circulatory system feeble. It may probably be asked why other organs, as well as the skin, do not exercise, during fœtal existence, their several functions. There is, in my opinion, a great difference between the exciting causes of the function of the skin and those of the recrementitious and excrementitious functions. *The functions of the kidneys and the liver appear to depend exclusively on the changes which food undergoes in the stomach, or on the constant admixture of nutritious and other substances with the circulating fluids of the body.*

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* Practical Treatise on the Parturition of the Cow, by EDWARD SKELLETT, Professor of the Veterinary Art.

If this were not the case, the kidneys of the fœtus would secrete an abundance of urine, as they are supplied with arterial blood, from which all secretions are derived. The investigation of this subject, in the present state of our knowledge, could lead to no satisfactory conclusion, and I shall therefore decline the consideration of it. It is quite sufficient for my purpose to know, that when the system is nourished by its own functions, the excretory organs are excited to a degree proportionate to the energy of these functions; and that, when they are not in operation, those organs do not exercise their ordinary offices. It has already been stated that the cutaneous surface of the fœtus is not unfavourably situated for secreting its respective fluids ; it is immersed in the *liquor amnii*, which, being of its own temperature, by stimulating the action of the capillary vessels, will promote *transudation.*

It has never been doubted that the whole surface of the adult body perspires ; but there are many disputes concerning its power of absorbing. On this subject, writers of the greatest authority in physiology differ in opinion : some assert that the skin absorbs ; others maintain that it cannot, unless its natural function is disordered by the application of acrid substances, by long maceration, or by the employment of friction. I am inclined to think that the latter is the more correct assertion, and in support of it, I may quote the words of my learned friend Dr. MILLIGAN :—

" The cuticle has no absorbing orifices opening on its surface, and the substances, hitherto supposed to be taken up by these, really make their way into the body by the action of the lungs and *cutis vera ;* yet, from the imbibing faculty common to the cuticle with dead or inorganized matter, many substances may, by long maceration or external violence, find a passage through it to the absorbing orifices of the *cutis vera* without any laceration of the cuticle being visible."*

Many cases are recorded, which prove that the fœtus is liable to be affected with the temporary diseases and derangements of the mother. How often does it happen that it is sickly or puny, if she has been much indisposed during pregnancy; being sometimes even expelled before its time, from a disordered or enfeebled state of the maternal system? The diseases of the fœtus, and the character of its constitution, almost demonstrate the nature of the connexion existing between it and the mother. It is stated that the liquor amnii is sometimes extremely offensive in its odour, and when this takes place, it may, generally, be shown to arise from diseases of the parent alone, or from them in conjunction with the action of mercury.†

It is almost unnecessary to state, that the combination of these causes infects the circulating fluids of the mother, and consequently, if the blood which the fœtus receives be unhealthy, it is not improbable that the skin will indicate the existence of diseased properties in its secretion. It does not necessarily follow that the fœtus shall be sickly, or imperfectly developed, because it has been supplied during one part of gestation with blood of an impure quality. During this time it may have made little progress, or have been rendered very weak; but in proportion as the parent recovers her strength, and usual vigour of constitution, it gradually recruits its powers, and may come into the world with all the attributes of a healthy being.

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* Notes to MAGENDIE's Physiology, trans., p. 508.

† Edinburgh Medical Essays, Vol. II., p. 283.

The correctness of this opinion, however, has been called in question. The mother may not indeed completely recover her ordinary degree of health, or the child may have been almost destroyed by her long continued diseases, or by the influence of deleterious medicinal substances: in either of these cases, it cannot be expected that the fœtus should be strong and healthy; but when these causes are less injurious, their effects are often wholly removed by an improved state of the maternal system.

It has been observed by those, who have paid attention to the physiology of the fœtus, that the liquor amnii, in the early months of pregnancy, is a comparatively clear fluid, and becomes cloudy or less pellucid as gestation advances. The amnios, like most secretions of the body, is a combination of salts and animal matter: the exposure of which, for several months, to a temperature of upwards of 90°, will account for all the changes in its nature and appearance.

The preceding remarks, explanatory of the origin of the liquor amnii, are founded on physiological facts, and supported by obvious and conclusive reasoning. I have not supposed the existence of any function which is not satisfactorily ascertained; nor have I attributed to it inordinate or unusual powers. The same method of inquiry will probably account for the production of the meconium, the bile, and other substances in the stomach and intestines of the fœtus.

It was stated in the preceding pages, that there is a great difference in those causes, which excite the action of the skin and the functions of the chylopoietic viscera of the fœtus. The latter, for their operation, are dependent upon the digestive process, or are particularly influenced by it. The action of the former is very much increased by the general exercise of the internal organs, as is particularly evident after birth; but it seems capable of continuing even during the immersion of the fœtus in the amnios, when the internal organs are inactive.

Although there is this striking difference, it is only in degree. The mucous membrane, the pancreas, and the liver, receive, during fœtal existence, arterial blood, in order to render their organization complete; and although they are not stimulated into extensive action, as at a subsequent period, by the digestive process, exercise, and other causes, yet it is impossible for them to be regularly supplied with sanguineous fluid without certain effects being produced, indicative of the partial activity of their functions. The meconium, the bile, and other substances, are then the production of certain organs thus partially exercised.

It has been asserted by those who imagine the qualities of the amnios to be nutritious, that this fluid is digested by the fœtus, which, in their opinion, receives it, and that the meconium is the effect of this operation. This opinion is supposed to be strengthened by the fact, that hairs have been occasionally found in the intestines of the calf, which must be allowed to have descended with the liquor amnii into the stomach. That such a phenomenon may occur is not improbable; but the calf does not require either the amnios or the hairs. If this fluid passed into the stomach, there is not the slightest reason to suppose that it would disorder the delicate system of the fœtus. It continues to grow in those cases in which many important organs are wanting, and it is consequently inconsistent to suppose that either a small or large quantity of the amnios would produce any derangement whatever. It is a matter of trifling importance, not at all affecting the argument, whether the mouth be wholly open or closed. *The meconium appears then to be nothing more than the admixture of the different secretions of the abdominal viscera, and is not, in any degree, the result of a regular digestive process.*

CHAP. VII.

THE NUTRITION AND PECULIARITIES OF THE FŒTUS.

After having so fully discussed the principles of fœtal nutrition, it may probably seem altogether unnecessary to make any further observation on the subject; but there are several points still remaining unexamined, that are too interesting and important to be passed over in silence. I have endeavoured to prove that the nourishment of the fœtus is derived exclusively from the arterial blood of the mother. This opinion has been supported by illustrations and arguments of a general and particular nature, and in no instance have I had recourse to abstruse or unintelligible hypotheses, in order to remove any difficulties connected with the subject. How different has been the manner in which some other physiologists have pursued their inquiries, and endeavoured to establish their opinions!

Bichat, in attempting to account for the extraordinary growth of the fœtus, supposes certain vital properties or forces to exist, whose nature and mode of operation are enveloped in the greatest mystery, and these are also brought forward by others, in explaining the actions of organic life. They seem not satisfied with attributing to nerves, merely the powers which they are proved to possess, as motion and sensibility, to organs which secrete or absorb, an unknown mechanism, and to the blood, qualities essential to the various purposes of the system. The human mind, in its eagerness to make new discoveries, is prone to render obscure what is plain ; always supposing that something more lies concealed than it has yet found out. Continually hunting after novelty, it, therefore, often forsakes the legitimate objects of inquiry, and amuses itself with its own delusive creations.

In this way, it ascends from obvious and simple facts, to others less apparent and more complex ; and from these again to others, which it is still less able to comprehend ; till, at last, it loses itself in the wildest and most absurd speculations, without being sensible of its folly. There is no science, in the study of which so evident a deficiency in the exercise of the common reasoning powers of the mind has been manifested, as in that of physiology.

It is often stated, with little credit to the medical profession, that, although our acquaintance with the animal system, and with general science, is more intimate and exact than that of our predecessors, our skill in the treatment of diseases has not made a progress proportionate to our knowledge. There is too much truth in the assertion. Ages distinguished for superior information, instead of improving the inexact sciences to the degree that might be expected, are not unfrequently carried by extraordinary and unsteady impulses beyond the just boundaries or objects of philosophy, as the fine-mettled racer is hurried past the prescribed limits of the course, by the additional speed acquired in running over it. Although men of extraordinary talents enrich the world with splendid discoveries, yet it is not uncommon for the greatest errors in science, or drawbacks to its progress, to arise from the same individuals. They often perceive what is true, but, dissatisfied with its obvious limits, and desirous of penetrating beyond them, they fill up the vast distance between what is known and unknown, with their own dreams and speculations. These, from the influence which the highly respectable authors of them exert on public opinion, make an impression on the minds of others, unfavourable to the detection of error and the discovery of truth. This is one cause of the humiliating fact, that every age is employed in correcting the errors of that which preceded, and contributing its own, to be detected in turn by that which shall succeed it.

The discovery of the circulation of the blood will, ultimately, be acknowledged to be one of the greatest blessings ever conferred on mankind. Its value has not yet been duly appreciated. The mere knowledge that blood is constantly flowing through the lungs and the system, according, in part, to the principles first laid down by the immortal HARVEY, considered separately, as an insulated fact, is of little importance; but *the knowledge of the various modifications of which this fluid is susceptible, will, hereafter, form a broad and immoveable basis for the grand principles in medicine. By observing the influence of different seasons, the effects of disease, and the changes induced by other causes, on the sanguiferous system, we shall ascertain facts of universal practical utility.*

I am not, I believe, too sanguine in my anticipations, when I state, that an acquaintance with these truths, will completely subvert the present doctrines of nervous affections; the prevalent ideas respecting the cause of animal temperature; the common notions of the susceptibility of the body to morbid action; and the views generally taken of the origin of acute and chronic diseases, as well as many other corporeal derangements.

Bichat, in endeavouring to account for the rapid development of the fœtus, observes,—"Ajoutons à la grande simplicité de l'assimilation dansle fœtus, la grande activité des organes qui y concourent, activité qui dépend de la somme plus considérable de forces vitales qu'ils ont alors en partage. Toutes celles de l'économie semblent en effet se concentrer sur les deux systèmes, circulatoire et nutritif; ceux de la digestion, de la respiration, des secretions, de l'exhalation, n'étant que dans un exercice obscur, n'en jouissent qu'à un faible degré: ce qui est de moins dans ceux-ci, est de plus dans les premiers. Si nous observons maintenant que les organes de la vie animale, condamnés à une inaction nécessaire, ne sont le siége que d'une très-petite portion de forces vitales, dont le surplus reflue alors sur la vie organique, il sera facile de concevoir que la presque totalité des forces qui, dans la suite, doivent se déployer généralement sur tous les systèmes, se trouve alors concentrée sur ceux qui servent à nourrir, à composer les parties diverses du fœtus, et que par conséquent tout se rapportant chez lui à la nutrition et à l' accroissement, ces fonctions doivent être marquées, à cet âge, par une énergie etrangère à tous les autres."*

That the system possesses certain vital properties, which can move to different organs of the body, accumulate in one part of it, or diminish in another, as they may be required, is an opinion almost universally prevalent, in one form or other, in medical works. The adoption of this hypothesis saves the physiologist a great deal of trouble, in those cases in which he is desirous of solving difficulties, found to be inexplicable on any of the known operations of the system. The *sensorial* power of DARWIN, the *excitability* of BROWN, and the *nervous influence* of WILSON PHILIP, are examples of these properties, of the existence of which, in the sense understood by their propounders, we have not the least evidence. That the constitution is endowed with certain vital powers, capable of repairing injuries done to the body, of performing the process of nutrition and the different actions of organic life, and susceptible of excitation and depression, cannot for a moment be doubted. But these powers, although truly extraordinary in their capabilities, are entirely dependent on arterial blood, or, in other words, *are the oxygenated and nourishing qualities of this fluid acting in accordance with the laws which regulate its circulation and its influence on the frame.* The fœtus is not rapidly developed, in consequence of a concentration of vital properties, nor is its growth, as BICHAT imagines, accelerated by the inactivity of certain functions. The arterial blood transmitted to it requires no elaboration in its own system to become nutritious; and it is of no importance to the vessels which absorb and apply the fluid to the necessities of the body, whether it is produced and perfected in their own system, or that of another. *The nutrition and growth of the fœtus and of the adult are regulated by the same principles.* When an organ is more abundantly supplied than usual with arterial blood, it is enlarged, and its function is often proportionably augmented. If the quantity of blood transmitted to the lower extremities is diminished by disease, they become emaciated; but, in this case, are the vital properties, formerly active in them, necessarily concentrated in some other part of the system? Inflammation, whether it attacks the heart, or the kidneys, produces an enlargement of these organs, arising from their increased vascularity.

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* Anatomie Générale, Art. IX. De l'Origine et du Développement de la Vie Organique.

Physiologists are continually alluding to the influence of mind on digestion and nutrition, observing that the vital energies, which ought to be properly divided between the animal and the organic functions, are often so much absorbed by the former, as to prevent the healthy exercise of the latter. It is true, that great mental application is capable of deranging those actions essential to life, but not in the manner generally believed. The child, from its restless disposition, and incessant tendency to muscular motion, is subject to greater relative expenditure of vital power than the adult, yet its functions of digestion and nutrition are more active. If the fœtus, at the seventh month of pregnancy, be supposed to provide for its own support in the uterus, by means of respiration and digestion, instead of these retarding its development, from a concentration of vital properties requisite for their action, they would accelerate its progress. Whenever the quality of the blood is improved by muscular exertion, by the buoyant feelings of the mind, or by any other cause, every part of the body acquires greater vital energies. The improvement is general, because it is derived from the sanguineous fluid which circulates throughout the system.

It has already been stated, in the preceding pages, that the umbilical vein carries arterial blood from the placenta to the fœtus. This opinion is supported by Drs. BOSTOCK and JEFFREY. Physiologists in general are either opposed to this conclusion, or consider it doubtful.* It is really astonishing, that a subject so easy to investigate, and to decide by experiment, has been allowed to remain so long undetermined. From the kindness of my friend Mr. CARR, surgeon, Sheffield, I have been enabled to prove, by an experiment of the simplest kind, that the umbilical vein circulates arterial blood. The following was the method employed by Dr. JEFFREY :—He took part of the cord, and dissected away the gelatinous substance of it, until he had laid bare the vessels, when, on puncturing them, he observed that there was a difference of colour between the blood in the vein and the arteries. Many physiologists are said to have failed in this experiment. From the tedious preparation which it required I did not succeed to my full satisfaction. But on taking part of the cord, as soon as the child was born, around which I had previously tied a ligature, about two or three inches from the free extremity, and cutting this with a sharp scalpel, in order to make an even surface, I very clearly discerned, on pressing the cord from below upwards, blood of a very different colour, flowing from the umbilical vein and arteries. If the experiment does not fully succeed in the first instance, tie a ligature still farther removed from the end, and, having made a fresh surface, press gently from below upwards. Sometimes a large drop of florid blood is observed to stand directly over the umbilical vein, and another dark coloured over the arteries, without their being in the least mingled with each other, and, in this case, the difference between the two is so striking that no one can fail to observe it. This experiment being so simple, and requiring no previous preparation, any individual of the most ordinary powers, or unscientific character, may easily perform it.

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* BICHAT, treating of this subject, observes, " Les faits précédens suffisent au reste pour établir, comme un fait incontestable, l'uniformité du sang des deux systèmes chez le fœtus."

It is an interesting and important inquiry whether the whole of the fœtal blood flows through the umbilical arteries to the placenta, in the same time, as the whole of the sanguineous fluid of the mother circulates through the lungs, viz., in about three minutes. If such be the case, the fœtus will have the whole of its blood renewed as frequently as that of the maternal system. *There is certainly the same relation between the heart of the fœtus and the quantity of blood belonging to its body, as there is between the heart of the adult and the quantity of blood circulating in its system.* If this assertion be allowed to be correct, and it is almost impossible to deny its accuracy, we shall be able to estimate the difference between the properties of fœtal and maternal blood. At every contraction of the left ventricle of the heart in the adult, a certain quantity of blood is expelled, the whole of which must inevitably return to the right auricle and be sent to the lungs, before it can arrive at the point from which it departed. This revolution is supposed to be performed in about three minutes. The blood transmitted at every contraction of the left ventricle of the heart of the fœtus, does not return, in the same manner, to the right auricle; one portion is sent to the internal iliacs, and conveyed from them to the placenta, by means of the umbilical arteries; another pursues its regular course, circulating from arteries into veins, until it arrives at the right auricle, where it is blended with the arterial fluid derived from the umbilical vein which terminates in the vena porta and vena cava inferior. This peculiarity in the circulatory system of the fœtus appears calculated to produce blood of an inferior quality, and, indeed, the consideration of this circumstance, has induced Coleman, Professor of Veterinary Surgery, very incorrectly, to call the fœtal blood black.*

The whole mass of the blood of an adult circulates throughout the system once every three minutes, because the heart contracts about 75 times per minute; if it contracted oftener with equal or superior energy, the same quantity of blood would complete its revolution in considerably less time. The heart of the fœtus, instead of contracting 75 times per minute, contracts, at least, 120 times. In considering this subject, we must not forget, *that there is the same relation between the heart of the fœtus and the quantity of blood belonging to its body, as there is between that of the adult and the quantity of blood circulating in its system.*

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* Coleman on Natural and Suspended Respiration, p. 45.

It is therefore obvious, if the fœtal heart contracts 120 times per minute, that the complete circulation of the blood in its system will be effected in almost half the time of that of the adult, and consequently, although venous blood is always mingling with the arterial fluid of the umbilical vein, the blood of the fœtus cannot be particularly deteriorated from this circumstance, because the whole mass is frequently renewed by the very numerous contractions of the heart. If this contracted 75 times instead of 120, the relation between it and the mass of the circulating fluid remaining the same, the arterial qualities of the blood would be diminished almost one-half.

The *foramen ovale* is a striking peculiarity of the fœtus, and it is not difficult to comprehend its use. In the adult the blood passes from the right cavities of the heart to the lungs in order to be oxygenated, but, as the lungs of the fœtus are perfectly quiescent, it would have been not only unnecessary, but impossible, from their collapsed state, for the blood to circulate through them. The position of the fœtus is calculated to produce a considerable diminution in the capacity of the chest, as will appear from the following description of it. "The spine is bowed forward; the head bended towards the knees; the thighs are brought forward; the legs bended back; the arms hung down, but are drawn a little forward; the hands and fingers are all bended."* When it is born, the lower extremities, that were before folded upon the abdomen, and the head that was inclined towards the knees, assume other and very different positions. The limbs are pendent, and the head becomes comparatively erect. These alterations, by increasing the capacity of the chest, admit into the lungs atmospheric air, which admission immediately changes the peculiarities of the fœtus. The blood that before flowed along the ductus arteriosus to the aorta now passes through the pulmonary artery to the lungs. As soon as these organs are inflated, their capacity is increased to a very great extent, and the augmentation of surface, for the distribution of blood, acts like a partial vacuum for the sanguineous fluid propelled from the right ventricle. It flows in the direction of the lungs, because it meets here with less resistance from their inflation, and the more direct course of the pulmonary artery.

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* MONRO, Edinburgh Medical Essays, Vol. II., p. 304.

As those causes which give the first permanent direction to the blood from the heart to the lungs, continue in constant operation during life, the ductus arteriosus is ultimately obliterated. This view of the origin of pulmonary circulation will enable us to explain the way in which the *foramen ovale* is closed. During fœtal existence the greater part of the blood received by the right auricle passes into the left through the *foramen ovale;* but as soon as the lungs are inflated, this blood flows with greater facility to the right ventricle, *and therefore, the pressure of the blood derived from the pulmonary veins, is as great upon the internal parietes of the left auricle, as that upon those of the right, in consequence of which the valve is kept completely closed.*

CHAP. VIII.

THE BRAIN, THE SPINAL CORD, THE STOMACH, THE LIVER, THE PANCREAS, AND THE INTESTINES, ARE NOT ESSENTIAL TO FŒTAL LIFE.

DEVIATIONS in the animal economy, from the usual course of nature, are of infinite value in inquiries concerning the office of any individual organ. It requires no ordinary powers of mind to discriminate the character and extent of assistance derived from a multiplicity of organs, as long as they exist and operate simultaneously; but whenever they are defective in number or conformation, it is then less difficult to ascertain the particular functions of each.

If physiologists had regarded monstrosities, as irregularities of nature, peculiarly adapted to indicate the character of those means which effect the diversified actions of the animal system, they would not, as they are at present, be enveloped in so much mystery and doubt. Prejudice in favour of preconceived opinions and theories, not unfrequently disables the physiologist from clearly perceiving the light which monstrosities throw on the operations and relations of organs. He, for example, who supposes that digestion, nutrition, and secretion are accomplished by nervous influence, is confounded when a well nourished fœtus presents itself, in which neither brain nor spinal cord exists; yet rather than lay aside his preconceived opinion on this subject, or take a more extended view of it, he has recourse to the most improbable explanation. If but a small portion of brain exists, this, he imagines is amply sufficient to supply the necessities of the fœtus; if it be entirely wanting, he concludes it had an existence at the commencement of fœtal life, but has since been absorbed by disease; or he considers the ganglionic system, which is perfect, as fully qualified to supply the place of the brain and spinal cord; or, perhaps, he still more presumptuously asserts, *that the uterus is a kind of Galvanic battery, for the purpose of furnishing to the fœtus an abundance of its mysterious fluid.* I have through the whole of this treatise, endeavoured to show that the fœtus receives arterial blood, and, that therefore, the chylopoietic viscera are not essential to its existence. It has, also, been observed, that the value of every organ in the adult, whose function is of a *primary* nature, is proportionate to the quantity of chyle produced, which becomes arterial blood when oxygenated in the lungs.

Since the fœtus is in precisely the same circumstances, in regard to nutrition, as a person would be who should receive arterial blood from without the system, it may be easily understood why it continues to grow when destitute of brain, spinal cord, stomach, liver, or intestines. Monstrosities are so far from furnishing any ground of objection to the views and explanations proposed in this treatise, that they even afford invaluable proofs of the correctness of every general principle advanced in it.

It must be allowed, that the object of the *functions of the primary organs is to provide the system with arterial blood, and, this being granted; it is quite manifest that these functions are not essential to the fœtus, as it is supplied with arterial blood from another source.* The imperfections of organization, varying in degree and kind, lead to a knowledge of the individual actions of the different organs of the animal frame. When a fœtus is observed to be supplied with nourishment, in which neither brain nor spinal cord exists, or in which the liver and stomach are wanting, the obvious inference is, that its nutrition is independent of these organs. Such facts simplify and, as it were, indicate the proper mode of investigating the physiology of the fœtus. They confine the attention of the mind to fewer objects, and illustrate the nature of those which are investigated. The following observations of De Candolle, on the subject of vegetable monstrosity, are extremely just and forcible :—

“ En particulier, toute cette nombreuse classe de faits, connue sous le nom de monstruosités, qui était impossible à comprendre dans l’ancien système, et qu’on affectait de mepriser pour se dispenser de les étudier, toute cette classe, dis-je, a pris une clarté et un intérêt nouveau, depuis qu’on les a vus sous leur vrai point-de-vue, savoir comme des indices pour reconnaître la symétrie normale ou primitive des êtres. Les monstruosités sont, pour ainsi dire, des expériences que la nature fait au profit de l’observateur : là nous voyons ce que sont les organes, quand ils ne sont pas soudés ensemble ; ici nous reconnaissons ce qu’ils sont réellement, quand une cause accidentelle ne les a pas empechés de grandir. Et en partant ainsi de l’opinion, que la nature primitive est la symétrie, que l'irrégularité est le produit de diverses causes qui altèrent cette symétrie, nous concevons que les monstruosités sont dues à certaines variations dans ces causes, et qu'elles peuvent, par-conséquent, tantôt nous faire connaître les causes de dérangement quand leur action a été augmentée ou débarrassée de toute complication; tantôt nous montrer l'état symétrique, quand les causes qui l'altéraient ont été ou affaiblies ou détruites."*

However imperfect the fœtus may be, providing it can circulate the arterial blood it receives, it will continue to grow. Its chylopoietic viscera are not intended for immediate action, and consequently their co-operation is not required by the fœtus. For the following highly interesting case of monstrosity I am indebted to my friend W. JACKSON, Esq., Surgeon and Lecturer on Anatomy in the Sheffield Medical Institution :—

Mary Ward, aged 33, married woman, was delivered of her ninth child at 6 P. M., February 12, 1824. During pregnancy no symptoms occurred, excepting such as are peculiar to that state; but she presented a certain unhealthy appearance, indicated by a full, flabby, and somewhat anasarcous state of the body generally. She had suffered an abortion about twelve months previously to this labour.

The infant was of the female sex—full grown, strong, and vigorous; and every function appeared to be performed correctly. Its weight was seven pounds. The pulsations of the heart were 110 in the minute, and quite natural: no embarrassment in the breathing. The child never cried in a loud tone, but uttered a low moaning noise, such as newborn children will frequently make when free from much excitement. The feces and urine were regularly evacuated; and a frequent motion of the jaws and lips was observed. Fluids were swallowed with facility, and apparent eagerness. Every part of the body was well formed, except the head, the appearance of which was extraordinary. The superior vaulted part of the cranium was wanting. The eyes, which appeared unusually prominent, seemed on a level anteriorly with the horizontal section of the skull. Upon the centre of the cranial bone appeared a membranous bag covering a mass of the size of a large orange, divided into two hemispheres by a longitudinal depression. This substance was irregularly lobulated, and its consistence and colour were similar to those of the placenta or liver, and exhibited a very vascular structure. It communicated with the subjacent parts by a narrow neck. When pressure was made upon this substance, much apparent suffering was produced, and if the force was augmented, motion and respiration ceased.

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* Organographie Végétale, Tome II., p. 240.

The surface of the body appeared somewhat livid 18 hours after birth: 30 hours after the birth the cry became rather indistinct. At the end of 50 hours it had ceased to moan or cry, appeared somewhat livid and shrunk. The fine transparent membrane covering the tumour had lost its lustre, and had become shrunk.

Vomiting now frequently occurred; but the urine and feces were regularly evacuated. On various occasions, it was presented to its parent's breast, but never displayed any disposition to suck. The covering of the tumour now presented a livid colour, and the linen covering was soaked in the sanious and offensive discharge which issued from the parts. Sudden starts, and deep sighs, were now frequently noticed. This extraordinary being never opened its eye-lids, owing, it is probable, to the absence of muscular structure of these parts, as the os frontis terminated upon the plane of the superciliary ridges, or, it is as probable, from the defect of the nerves supplying the muscles of the face with power. To all appearance this child enjoyed the repose of sleep for a few hours on various occasions.

The subject of this case died on the 4th day, or 92 hours after its birth, and might be justly said, for the first two days, to have been, with the exception of the head, a healthy-looking, and vigorous infant.

Several examples of acephalous, or an anencephalous fœtuses (of which latter denomination this is an instance,) are recorded by writers in all ages; but in no instance did any of them survive for so long a period as in this case. They are almost all said to have been vigorous in their uterine existence, but appeared unable to support independent life. No motion of the iris occurred on the application of a strong light; but on a sudden noise occurring, the child appeared greatly agitated, proving the organ of hearing to be capable of performing its function.

POST MORTEM EXAMINATION.

The tumour extended by a membranous connexion through an opening occasioned by a deficiency of the bone, situated about three inches posterior to the orbits, and the posterior part of its base, by a similar connexion, passed down the spinal canal, and between these two openings was a firm long projection of an irregular figure. The anterior cavity was divided by a strong septum of bone of an irregular figure situated in a vertical direction. These cavities communicated anteriorly with the orbits, and posteriorly with the spinal canal. Nature appeared to have been particularly solicitous about preserving the integrity and due capacity of the orbits, and the optic foramina. The sinuses formed between the orbits and the bone of the tumour extended about 2½ inches. The bone of the cranium was of great thickness, and extremely irregular in its figure internally. A section of the tumour presented a mass resembling the placenta, containing throughout various sized cavities lined with a fine membrane, and filled with a limpid serum. This substance did not extend along the spinal canal, which was filled with the same kind of straw-coloured serum, like that which was contained in the cells of the tumour. There appeared some very slight traces of medullary substance, but we were not satisfied whether it was so or not.

The above case of monstrosity is not so extraordinary as some that are recorded, but it is valuable, as it shows that the fœtus, although destitute of brain and spinal marrow, received sufficient nourishment. Other cases might be mentioned, in which not only the brain and spinal cord were wanting, but also the principal abdominal viscera without the process of nutrition being in any degree lessened. For a full account of them the reader may consult the learned paper of Mr. LAWRENCE, in the Medico-Chirurgical Transactions,* and the London Philosophical Transactions.

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* Vol. V., p. 165. See also BOSTOCK'S Elementary System of Physiology, Vol. II., p. 413.

CHAP. IX.

ON THE FUNCTIONS OF THE LIVER, THE SUPRA-VENAL CAPSULES, THE THYMUS, AND THE THYROID GLANDS IN THE FŒTUS.

It is well known that these organs are proportionally much larger in the fœtus than in the adult. This striking difference in their size is probably occasioned by the great dissimilarity in the circulation of the blood before and after birth. In the infant there is a natural and constant tendency to indulge in muscular exercise; its frequent cries, and those external objects which almost incessantly call forth the expression of its various feelings, produce one general effect, viz. *a more equable distribution of blood.*

It is impossible for the circulatory system to be thus influenced, without, at the same time, more completely oxygenating the sanguineous fluid, and thus increasing its stimulating qualities, which produce and support a state of circulation that has, in the experimental inquiry, been called *external.* In the fœtus these exciting causes are altogether wanting; since in that there are neither continual contractions of the muscles, nor exhilarating states of mind; the heart alone being employed in diffusing the blood throughout the system. If, therefore, the blood circulates, in the infant, more equably throughout the body, from the co-operation of many causes, it is obvious that in the fœtus, in which most of these causes are absent, and others but imperfectly brought into action, the greater portion of this fluid being less favourably situated for general diffusion, will, consequently, be distributed to the internal organs, creating a state of circulation, which has been called in the work, to which I have just alluded, *internal.*

To prove the correctness of this opinion, it is only necessary to mention, that when the surface of the adult system is constricted by cold, or when the qualities of the blood are deteriorated by feelings of a depressing nature, the sanguineous fluid becomes rather *internal* than *external* in its circulation, and the whole of the abdominal and thoracic organs become congested, in a degree proportionate to their organization, situation, and function. From pain experienced in the chest, and the difficulty of breathing occasioned by irregularities in the distribution of the blood, it may probably be imagined that the lungs are congested to a greater extent than any other organs, but I am disposed to think, if the cause of these irregularities be general, the lungs are not so considerably engorged as the liver and the spleen, although these may give no particular indication of congestion. The former, from the delicacy of their function, and its vital importance to the well-being of the system, are, perhaps, sooner deranged than any other parts of the body.

The circulation of blood in the lungs, is more regular than in the liver and the spleen, on account of their vicinity and very intimate relations to the heart: from these and other causes, congestion will take place, to a less extent in the thoracic, than in the abdominal organs; yet the former will be more sensibly affected.

The *internal* character of the circulation in the fœtus, probably, arises from three causes:—

1. *The circulating fluid in the fœtus being an admixture of venous and arterial blood, is, therefore, not so stimulating to the heart and arterial system, as that of the adult, which is perfectly oxygenated.*

2. *The non-existence of muscular motion, which improves the qualities of the blood, and invigorates its circulation.*

3. *The absence of exhilarating emotions, and occasional internal stimulants, as food and drinks.*

Taking this view of the subject, the accuracy of which can scarcely be called in question, an engorgement of the abdominal organs of the fœtus, ought not to be a matter of surprise, since it is a natural and necessary effect of the *internal* distribution of blood. It would, in my opinion, have been more extraordinary, if these organs had not been found in a state of congestion, because, in that case, the views which I have stated in the Experimental Inquiry, and which are, I believe, generally allowed to be fully established, explanatory of the manner in which the circulatory system of the adult is influenced by cold, muscular exercise, and the various emotions of the mind, would have been incorrect. We may, therefore, conclude, that the large size of the liver in the fœtus, arises from the great quantity of blood which it receives, and the inactivity of those causes which invigorate the general circulation. The *supra-renal* glands are also observed to be very large in the fœtus. These I am inclined to consider *diverticula,* operating more or less in every period of life, in order to secure the proper and regular action of the kidneys, which are liable, at times, to be disordered by irregularities in the circulation. Nature has, throughout the animal economy, protected the most essential organs from sudden destruction or derangement. The five senses have their appropriate means of preservation; the heart and the lungs are secure from external injury by the strong parietes of the chest, and from occasional congestions by the liver and the spleen; and other organs, as the kidneys and the larynx, have also auxiliary appendages, which render them less liable to disorder.

There is a striking difference between the structure of those organs which directly support the system by their respective functions, and that of others, which I suppose to act wholly, or in part, as *diverticula.* *The former are susceptible of increase of volume in one way only, by an accretion or growth of new matter; the latter are capable of great augmentation, without any permanent addition being made to their substance.*

The heart and the kidneys, for instance, in consequence of inflammation, or the circulation of blood of a highly nutritious quality, are sometimes augmented to twice their usual size; but when the cause which produces this enlargement ceases to operate, no diminution of these organs takes place. The liver, the spleen, the supra-renal capsules, and the thyroid gland, on the contrary, though often very much enlarged, from internal determinations of blood, arising either from cold, disease, or depressing emotions, return to their natural size, when the cause of the augmentation is removed. This difference in the structure of organs, and the peculiarities of the circulation before birth, sufficiently account for the great size of the liver, the supra-renal capsules, the thymus, and the thyroid glands, in the fœtus. These, from their organization, admit of great increase; and as the blood is *internal* in its distribution, their enlargement is a necessary consequence. The thyroid gland, from its structure, and relations to the larynx, is well calculated to protect the organs of voice. The thymus gland, probably, performs, though in a less degree, the same office in the child, until these parts are fully formed.

From the congestion of the abdominal, and other organs of the body, at the time of birth, it cannot be denied, that a greater proportional quantity of blood is then circulating in them, than some months after this period. Is not this additional quantity to be regarded as a reservoir from which those parts of the body are supplied, which receive but little of this fluid during fœtal existence? The lungs, the extremities, and the surface of the body, are possessed of no more blood than is absolutely necessary for their development; but, immediately after birth, great modifications take place in its distribution. The lungs, that were previously collapsed, become inflated with air, the capacity of the chest is increased, and a considerable proportion of blood is sent to the thoracic organs; the extremities, from their altered position and frequent action, require an additional quantity of blood; and the surface of the body, from the co-operation of many causes, as the stimulating effects of atmospheric air, muscular motion, and the more highly oxygenated properties of blood also, requires a greater supply of this fluid. If the system, at this time, did not possess a superabundance of blood in the internal organs, would not those parts of the body, which I suppose to be supplied from it, be imperfectly supported, until the *ingesta* of the infant had created a sufficiency of arterial blood? Whether these views be fully or partially received, it will not be denied, that the enlargement of the abdominal and other organs in the fœtus, is explained on principles which have been minutely and, I trust, satisfactorily stated in the Experimental Inquiry, in which I have shown how the circulatory system of the adult is influenced by various causes.

CHAP. X.

THE MODE OF NOURISHMENT IN THE OVIPAROUS AND THE OVO-VIVIPAROUS ANIMALS.

THE more we study the operations of nature, the more we are convinced that she

> "Acts not by partial, but by general laws."

This fact is proved by a patient and extensive investigation into the designs and actions of animal and vegetable life. Whenever the principle of vitality is connected with organic instruments, whether they adapt the plant to one particular spot, for the purpose of vegetating awhile, and then dying, or enable the animal—organization in it being more perfect and diversified—to gratify its complex wants, the existence and transmission of life are secured by similar laws. The external forms of animated nature are almost innumerable. In the production of these, the Creator appears to be lavish of his means, as if acting independently of any pre-ordained plan, or as if desirous of exhibiting the unlimited extent of his power: but, although his works are thus infinitely varied in form, the provisions essential to life, as absorption, assimilation, and aëration, are of the same general character in every living and animated being. If we confined our view to the various external forms of organized nature, without regarding the universal properties that pervade the animal and vegetable kingdoms, we might be inclined to deny the correctness of this important principle, or to conclude, at least, that in the present state of our knowledge, it was not sufficiently established. Its truth or falsehood can be determined only by ascertaining what functions of those which support life, in the most perfect animals, are *primary*, and what are *secondary*. In the preceding chapters, I have endeavoured to show, that the object of the *primary* functions is to produce arterialized blood, understanding by this term, a fluid possessing oxygenated and nourishing properties; and that when these functions are multiplex, as in man, the secondary are proportionally numerous and active; *the latter are to be regarded as effects, the former as causes.*

In confirmation of this view, I have observed, that in the most simple forms of animal and vegetable life, the organic instruments indispensably requisite to support existence are few, that those organs, therefore, whose office is to remove the non-essential products, are also few. But, however low we descend in the scale of being, there are certain parts of the system which are always perfect, viz : — *those which absorb nourishing materials from without, and those, which, by means of atmospheric air effect certain chemical changes within.* It is by the employment of these, according to general principles, from which she never deviates, that nature has preserved a surprising uniformity in all her works.

If the benevolent Author of Life had been solicitous to provide for the existence only of his creatures, He would not have bestowed on them so great a variety of forms, such different degrees of motion and sensibility, and such a diversity of organic adaptations, as we observe throughout the extended range of his productions. The numerous superabundant properties He has added to the apparatus of means, necessary to preserve existence in the series of animated beings, ascending by very gradual steps, from the simplest development of animal life, to the complex construction of the human frame, " fearfully and wonderfully made," are evidently designed to contribute to the greater happiness of each, and to fit it for its particular place in creation. Whether we watch the sports of the finny tribe on a fine evening in summer, or observe the playful motions of the insect race, or listen to the melodious strains of birds, or take a general view of the manifestations of enjoyment, as exhibited by animals of every kind, both wild and tame, or notice the indications of pleasure in the human race, physical as well as mental, we are compelled to acknowledge that the great and good Creator has bestowed not only life, but innumerable blessings in connexion with it, on all the beings He has made. "Sic natura, ceu benigna ac indulgens mater, abundare potius superfluis, quam in necessariis deficere maluit."

The diversities apparent in the animal and vegetable kingdoms, in the external forms, internal adaptations, and various powers belonging to living matter, have a tendency to render extremely difficult a knowledge of the principles, in themselves few, simple and universal, observed in all the works of nature. As one not deeply versed in mechanics is apt to be confused in attempting to appreciate the relative value of the different parts of a machine which is complex in its construction, so he, who endeavours to ascertain the important laws which regulate the economy of nature, if he neglect to strip the objects he investigates of properties bestowed upon them for the wisest of purposes indeed, but not for the support of life, is liable, at every step, to be perplexed or to form theories respecting the subject of his investigations which are partial and imperfect. He, who studies the laws of motion belonging to inert matter will find all his efforts vain to comprehend or apply them to any useful purpose, unless he first confine his attention to the simplest examples which illustrate them. By the study, however, of such examples he will readily discover the primary or essential principles of motion, and will afterwards be able to perceive amidst the greatest multiplicity of parts and variety of action, a strict adherence to general laws. By adopting a similar plan, — by a close and careful inspection of those living productions, whose organization is of the simplest description, the investigator of the operations of nature will readily perceive the means by which vitality is maintained in them, and as he traces the gradual rise in the scale of being he will find the same means continually employed under every difference of external form or appearance. If this mode of judging nature had been strictly followed in physiology, we should long since have possessed correct and settled notions concerning the vital functions of the body, and the cultivators of this science, instead of attributing, as they have done, the most important powers to nerves or imaginary principles, would have referred them to organs that exist, under different forms, throughout the whole extent of the animal and vegetable kingdoms, and not to those which belong only to a part of the animal creation.

The same method which I have recommended as proper to be pursued in order to arrive at a knowledge of the primary or essential functions of animal and vegetable life, ought to be adopted for the purpose of ascertaining the general laws which regulate the nutrition of the ova of oviparous and ovo-viviparous animals. In reviewing the different opinions which physiologists, both ancient and modern, have entertained on this subject, it is to be regretted that a more frequent recurrence to the sound principles of philosophy, has not characterized their laborious and valuable exertions. HARVEY devoted many years to this part of comparative physiology, but his observations upon it, are not distinguished by that comprehension of mind and correctness of reasoning, which are so strikingly displayed in his well-conducted experiments and their ingenious application, to demonstrate the circulation of the blood.

The spirit of generalization, which ought, at all times, to keep pace with our advancement in science, has led him into palpable absurdities. In regarding the nourishment of the embryo in the egg, as depending on the contents of the shell, the yolk and albumen, and the conjoined action of air derived from the atmosphere, he has not brought forward any original opinion, though the correctness of this view is not to be doubted : but, in applying these facts and reasoning to elucidate the difficulties connected with the nourishment of the human fœtus, he has erred. The analogy which, in the following passage, he states to exist between them is only imaginary, since they have no resemblance, whatever, to each other. "Manifestum itaque est, in illis, atque etiam in his (cæterisque forsan omnibus)

animalium viviparorum speciebus, embryonem non aliter in utero, quam pullum in ovo, sustentari; ex eâdem scilicet materiâ alibili, specieque simili albuminis nutrimento. Enimvero ut in ovo, vasorum umbilicalium fines in albumine et vitello terminantur: ita pariter in cervis et damis, aliisque, quibus hujusmodi carunculæ insunt; ultima vasorum umbilicalium orificia, in humores, qui intra conceptum continentur; inque albumen, quod in acetabulis cotyledonibusve istis est, aperiuntur, et desinunt."*

Sir E. HOME has deviated as widely from the truth in the hypotheses which he has formed to explain the aëration of the blood in the human fœtus. Having observed, as HARVEY had previously done, in regard to the oxygenation of the blood in the egg, the various contrivances of nature, in the different classes of oviparous and ovo-viviparous animals, for the purpose of aërating the sanguineous fluid, he concludes without sufficiently taking into consideration the dissimilarity of the circumstances, in which the embryo of the oviparous species and of the two preceding are placed, that the blood of the former is oxygenated from its exposure to the arterial fluid of the mother. As this is the only connexion he allows to exist between the fœtus and the parent, he is under the necessity of granting, that every thing belonging to the fœtus, viz., its gradual growth and constant nourishment, is the result of the oxygen which it is thus supposed to receive. "In quadrupeds in general, and the human species, the fœtal blood," he observes, "is aërated in a very different manner from that which has been described; for, although the fœtal circulation sends a portion of its blood to the whole of the membranes in which the embryo is inclosed, as in oviparous animals, the influence of the external air is excluded from the coats of the uterus, to which these membranes every where adhere. *The fœtal blood, is, however, close enough to that in the vessels of the uterus, to have the air in the maternal blood communicated to it.*" "From the series of facts which has been detailed," he continues, "it appears that oxygen is essentially necessary for the action of the vivifying principle in all classes of animals; and, that it is not simply applied to the blood, but mixed with that fluid while circulating in the arteries, since, if this were not the case, there would be no means of aërating the fœtal blood in the higher orders of animals."* No one can doubt the necessity of the presence of oxygen for the purpose of promoting the vital operations of the animal and vegetable systems, but, from his explanation of the mode in which this is accomplished during utero-gestation, he seems not to be acquainted with the very opposite means which are employed to effect the same purpose.

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* Exercitatio LXIX.

In the preceding chapters, I have shown, that the human fœtus is supported by the arterial blood of the mother, and, therefore, has no occasion, whatever, for those peculiar adaptations which have been universally provided for the nourishment of the embryo belonging to oviparous and ovo-viviparous animals. In the viviparous the fœtus is connected with the uterus by means of one placenta, which receives the blood of the mother and transmits it to the fœtus, whilst, at the same time, it receives the venous blood of the fœtus, and conveys it to the maternal system. The organic contrivances which secure this mode of circulation and oxygenation are common to the whole class of viviparous animals; but they differ materially in number, form, and magnitude in different species. "The placenta of the biscula is divided into numerous cotyledons, the structure of which is very interesting, as it elucidates the whole physiology of this organ. The parts designated by this appellation are certain fleshy excrescences (glandulæ uterinæ) produced from the surface of the impregnated uterus, and having a corresponding number of flocculent fasciculi of blood vessels (carunculæ) which grow from the external surface of the chorion, implanted in them. Thus the uterine and fœtal portions of the placenta are manifestly distinct from each other, and are easily separable as the fœtus advances to maturity. The latter only are discharged with the after birth, while the former, or the cotyledons, gradually disappear from the surface of the uterus after it has parted with its contents. The number and form of these excrescences vary in the different genera and species. In the sheep and the cow, they sometimes amount to a hundred. In the former animal, and the goat, they are, as the name implies, concave eminences; while, on the contrary, in the cow, deer, &c. their surface is rounded or convex."*

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* London Phil. Trans., Part II., 1810.

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* BLUMENBACH'S Manual, translated by LAWRENCE, p. 358.

It is not necessary to state the various peculiarities, in the different species of animals, of these organs which unite the fœtus to the uterus of the parent, for, whatever be their form or number, they perform the same important functions; and the general principles which regulate the nourishment of the human fœtus, operate in the same manner, in every instance, in which the young are thus intimately connected, by means of placentæ, with the mother.

I shall now endeavour to show the obvious difference which exists between the nutrition of the fœtus in the viviparous, the oviparous, and the ovo-viviparous animals. When the embryo of the viviparous is first perceived, it is not imbedded in a vast quantity of albuminous or nourishing matter, from which it is to draw its future sustenance, but is enveloped in an almost pellucid fluid, only a little more apparent than itself: after some days, when it is distinctly seen, it is firmly attached to the surface of the uterus, the connexion becoming more extensive as the fœtus is developed, and the waters, in which it is immersed, increasing in quantity, in proportion, as it approaches the period of parturition. But when the embryo of the oviparous, or the ovo-viviparous animals, is first observed, it is imbedded in the yolk and albumen, or in a gelatinous fluid, its future and only means of nourishment; and as the time of its expulsion draws near, the contents of the egg diminish, until, at last, not a particle remains.

HARVEY, observing that the fœtus of viviparous animals, when the time of its expulsion had nearly approached, was suspended in an abundance of watery fluid, imagined that this fluid bore the same relation to the young which it contains, as the yolk and albumen bear to the embryo which is inclosed by them. On the strength of this supposed analogy, he makes the following assertion:—“Ego nihilominus fidenter assero, dictos humores ab initio fœtui pro alimento esse; quemadmodum colliquamentum et albumina pullo in eum inserviunt.”*

There are three striking differences which completely demonstrate the inconsistency of this analogy.

In the first place, the embryo of viviparous animals is always connected with the uterus by means of one or more placentæ. In the oviparous, the fœtus is contained in an egg, and has no union whatever with the individual which has produced it. In the ovo-viviparous, the young is immersed in a nutritious fluid, but the membrane which envelopes it is not hard like the shell which surrounds the young of the oviparous, and although retained by the parent until it is fully developed, and capable of providing for itself, yet, during the time of its retention, it has as little vascular connexion with the mother as that of the oviparous.

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* De uteri membranis et humoribus.

Secondly, The fluid in which the fœtus of viviparous animals is suspended, augments in quantity as the period of parturition approaches; the albumen and yolk of the egg, in which the ovum of the oviparous is placed, and which are supposed to serve a purpose analagous of this fluid, diminish as incubation proceeds.

Thirdly, The ova of the oviparous and of the ovo-viviparous have certain manifest relations to the external world, which the fœtus of the viviparous has not.

These general and important differences are quite sufficient to show the inaccuracy of the analogy supposed to exist in the mode of nutrition between the fœtus of the viviparous and the young of the oviparous and the ovo-viviparous animals. The embryo of the oviparous is, as I have just stated, imbedded in the yolk and albumen, which are calculated to supply its necessities until it is fully formed, and is also possessed of organic adaptations which are fitted to aërate its circulating fluids. The organs of the incubated ovum do not in the least contribute towards the elaboration of the food which is essential for the growth of its various parts; and, therefore, certain contrivances, external to itself, must exist, in order to effect preparatory changes on whatever is intended for nutrition. The yolk and albumen are contained in separate membranes, and to promote, most probably, their absorption, there are two tassel-like appendices, called *chalazæ*, hanging from two opposite points of the external surface of the yolk-bag, and extended into the albumen. These seem to be entirely composed of vessels, and are, consequently, well adapted to absorb the albumen, and to carry it to the yolk-bag, the membrane with which they are connected, where it is assimilated to the blood, and applied to the nutrition of the embryo.

In the internal surface of the yolk-bag, innumerable vessels, with flocculent extremities, are found, intended, apparently, to perform in the yolk a function analagous to what is accomplished by the chalazæ in the albumen. " From the fourth day, when the chicken has attained the length of four lines, a vascular membrane, chorion, or membrana umbilicalis, begins to form about the naval, and increases in the following days with such rapidity, that it covers nearly the whole inner surface of the shell within the membrana albuminis during the latter half of incubation. This seems to supply the place of the lungs, and to carry on the respiratory process instead of those organs. The chorion, that most simple, yet most perfect temporary substitute for the lungs, if examined in the latter half of incubation in an egg very cautiously opened, presents, without any artificial injection, one of the most splendid spectacles that occurs in the whole organic creation. It exhibits a surface covered with numberless ramifications of arterial and venous vessels."*

Similar contrivances to oxygenate the blood in the incubated egg, exist throughout the whole class of oviparous animals. The ova are sometimes aërated by means of water, instead of atmospheric air, as those of salmon and trout; but in these instances, the membranes which envelope them, are similarly circumstanced to those of the chicken. No part of animated nature can exist without the presence of oxygen. This not only forms water, in its union with hydrogen, but is also diffused throughout this fluid. Hence the ova of certain fishes placed in the sand, and supplied with water, are acted upon by the oxygen it contains, in the same manner, as the egg during incubation, by atmospheric air. The ova of the ovo-viviparous are retained in the abdomen of the parent until the young are sufficiently developed to maintain their individual existence.

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* BLUMENBACH'S Manual, translated by LAWRENCE, p. 372.

Although these are apparently so intimately related to the mother, there is no vascular connexion whatever between them and her, nor do they derive any sustenance from her. They are enveloped, like the embryo in the egg, in membranes filled with a gelatinous substance, which is absorbed and elaborated for the purposes of nutrition. "When the young dog-fish is completely formed, the yolk remains attached to the belly by a long chord consisting of blood vessels, and the fish swims about in the surrounding jelly with this attached to it. If the bag is torn, and the fish is taken out and put into water, it swims about; but if the vessels going to the yolk are wounded, the fish immediately dies."*

The ova which are retained in the abdomen until the young are fully formed, have the blood oxygenated by means of sea water or atmospheric air, which easily passes to them through certain natural apertures. It is therefore evident, that the ova of the oviparous and the ovo-viviparous are nourished in the same manner.

The view which I have now given of the subject treated in this chapter, shows the solicitude of nature to secure a regular supply of oxygen to the ovum, whether immersed in water, or subject to the action of atmospheric air. Although, then, we may be disposed to agree with Sir E. Home, in regard to the necessity of oxygen, yet it is obvious he has erred in endeavouring to explain the manner in which the fœtus of viviparous animals has its blood aërated. In neglecting to take into account the great dissimilarity in the circumstances of the fœtus of viviparous, and those of the ovum of the oviparous animals, he has deviated from the sound principles which ought to direct our investigations into the works of nature, and has, consequently, advanced an opinion, which a careful study of the laws of the animal economy proves to be incorrect.

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* London Phil. Trans., Part II., 1810.

CHAP. XI.

THE INFLUENCE OF THE IMAGINATION OF THE MOTHER ON THE DEVELOPMENT AND CONSTITUTION OF THE FŒTUS.

THE mind has, in all ages, been supposed to have a powerful influence on the body. The consequences which occasionally arise from violent paroxysms of anger and fear, are commonly adduced to prove how greatly the system is excited or depressed by mental emotions. Although the precise manner in which the mind produces bodily derangement is not understood, yet it seems to have been universally allowed, that the nerves are the organs through which the impressions are directly transmitted. Whenever the uterus or liver appeared to sympathize with the disturbed state of the mind, the effect was formerly attributed to a nervous connexion existing between it and the disordered organ. The fallacy of this opinion has been proved in my Experimental Inquiry.* In the fifteenth chapter of that work, discussing the subject of passion, I have shown that, though the mind, in all cases of violent perturbation, acts on the body through the nervous system, its influence is not conveyed through the nerves generally distributed to the different organs, *but through those only which belong to the respiratory function.* The disturbance of this function is amply sufficient to account for every irregular action which may be occasioned in any part of the system. The very vague and unsatisfactory notions hitherto entertained on this subject, have given rise to the most absurd and extraordinay tales that ignorance could possibly invent concerning the influence of the maternal mind on the fœtus. That the mind is capable of exerting an important influence on the constitution and development of the fœtus, is a fact which I am not disposed to deny; but I do not hesitate to say, that this influence is not to be ascribed to any nervous connexion between the parent and the child in the womb; nor do I consider it probable, that all the cases which are related, as illustrations of mental agency can be clearly traced to this cause.

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* See Experimental Inquiry into the Laws which regulate Organic and Animal Life.

The female, during pregnancy, is sometimes highly susceptible of external impressions; and if it should so happen, that the offspring exhibits any appearance of malconformation, or peculiarity of physical construction, the mother is generally prepared to refer it to a well-remembered circumstance that occurred during the period of gestation. It is more agreeable to her feelings to explain its origin in this way, than to have it ascribed to any natural cause. From a similar feeling, individuals who are affected with certain hereditary diseases, occasionally exercise a little ingenuity to invent a plausible reason for them.

It is stated by Sir WALTER SCOTT, that the mother of BONAPARTE, LÆTITIA RAMOLINI, " partook of the dangers of her husband, during the years of civil war, and is said to have accompanied him on horseback on some military expeditions, or, perhaps, hasty flights, shortly before her being delivered of the future emperor."* We are not, from this circumstance, to suppose, as some writers have done, that the martial character of NAPOLEON is to be ascribed to the dangers and hardships which his mother experienced. The distinguished part which his father took in the wars, and the heroism which his mother displayed, in contending with difficulties and enduring privations, proved that they both possessed superior mental endowments. The likeness which children bear to their parents, either in mind or body, does not arise so much from the influence of external circumstances, during pregnancy, *as from the natural constitution, or from the peculiar state of the parental systems at the time of conception.*

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* Life of NAPOLEON BONAPARTE, Vol. III. p. 6.

If external causes operated directly on the fœtus, through the imagination of the mother, in all those instances in which she is, at any particular period of gestation, powerfully affected by any strong emotion of the mind, or acute disease of the body, her offspring would inherit, from birth, feelings and complaints similar to her own. But this is so far from being the case, that the child is often extremely healthy, and does not exhibit any physical or mental similarity to the parent. If it were invariably otherwise, we should be under the necessity of granting that the impressions transmitted from the mother to the fœtus, have the power of increasing or diminishing the substance of the brain, and thus changing the intellectual character. The mental powers depend on cerebral matter for their variety and extent: how, then, without some modification of it, could the faculties and feelings be influenced? In allowing that an emotion, communicated to the fœtus, can increase or diminish, either generally or partially, the nervous mass, we must conceive it to be endowed with extraordinary powers, and suppose the structure of the brain liable to be changed by every excited and depressed state of the maternal mind. Families have sometimes been distinguished for centuries by the same kind of intellectual powers and disposition; but if these were not transmitted agreeably to the general principles which regulate the organization of the body, the uniformity of the resemblance would not be preserved for so many years. Children as frequently resemble their parents in constitution of mind as in form of body; and there is no difficulty in accounting for the similitude in this respect, if it be allowed that mind depends on cerebral matter for its development, because the same unknown law which preserves a likeness in one material part of the system, may certainly preserve it in another. If this view of the subject be correct, we may account for the resemblance or dissimilarity between parents and children, in regard to intellect and disposition. It is recorded of the CLAUDIAN family, "Diu Romæ floruit, impigra, ferox, superba; eadem illachrymabilem TIBERIUM, tristissimum tyrannum, produxit; tandem in immanem CALIGULAM, et CLAUDIUM, et AGRIPPINAM, ipsumque demum NERONEM post sexcentos annos desitura."*

"The murder of DAVID RIZZIO," observes Mr. COMBE, "was perpetrated by armed nobles, with many circumstances of violence and terror, in the presence of MARY, Queen of Scotland, shortly before the birth of her son, afterwards JAMES the First of England. The constitutional liability of this monarch to emotions of fear, is recorded as a characteristic of his mind; and it has even been mentioned, that he started involuntarily at the sight of a drawn sword."† From this passage, and the tenor of the reasoning employed elsewhere, this amiable and philosophical writer appears to think that the timid character of JAMES is chiefly to be ascribed to the violent emotions which MARY experienced during pregnancy. "The mind of NAPOLEON'S mother," he says, "appears to have risen to the danger to which she was exposed, and braved it; while the circumstances in which Queen MARY was placed were calculated to inspire her with fear alone." If the accident had happened immediately after conception, or if it had directly preceded it, the highly disturbed state of mind, and the generally excited sensibility of the system, might have given rise to such a peculiarity in the offspring; but it does not seem probable that the constitution of the fœtus, when almost fully developed, is capable of receiving any important alteration from the mental emotion of the parent. Sensibility, motion, and the intellectual phenomena, are the attributes of different parts of the nervous system; and if we suppose a cause sufficiently great to change the character of these powers, we must also allow that the nervous mass, in which they are situated, is materially modified, or we must deny the necessary and intimate relations existing between the function of an organ and its structure.

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* Conspectus Med. Theoret., cap. I., sect. 16.

† COMBE on the Constitution of Man, p. 157.

If the imagination of the mother can influence the mental powers of the fœtus, when the cerebral organs have received their determinate forms, it would appear, that the impression which is communicated to it, is capable of changing the organization of the brain, or that its innate properties are independent of that organization. It is not very probable that a child is born with an impression which is altogether unconnected with nervous matter, and it is equally unlikely, that an *idea* can directly alter its natural qualities. The involuntary emotion which a drawn sword produced on the mind of KING JAMES, is not to be ascribed to any instinctive dread with which he was born, *but to his naturally timorous disposition, and the disagreeable associations connected with the object.* If he had been so educated as to regard the sword as an agricultural instrument, or had never been informed of the melancholy catastrophe with which it must ever have been associated in his own mind, or the dreadful purposes to which it is generally applied, he would not have started involuntarily at the sight of it, or, if he had, his mind would have possessed an intuitive knowledge of the accident, which is not very probable.

Sir E. HOME is one of the latest writers, who has endeavoured to support the direct influence of the maternal mind on the fœtus. He seems to consider the correctness of this opinion as proved by the discovery of nerves in the placenta, and the continuation of them along the umbilical cord. "'Till this discovery was made," he observes, "we had no mode of estimating the influence that could be produced upon the child by the affections of the mind or the body of the mother; and, therefore, the instances that have occurred, were considered as idle stories or accidental occurrences, for which no satisfactory reason could be assigned; and this on no better ground than that they do not always take place under similar circumstances, which nothing connected with nerves ever does."*

There are many objections to this mode of explaining the transmission of maternal influence, although apparently so simple and satisfactory. Let us suppose the nerves to be the medium of connexion between the mother and the fœtus. If, at one time, the disturbed state of the mind gives rise to a hare-lip, or a deformed body, it is surely not unreasonable to expect, that, at another, when a cause similar in kind and degree is in operation, some traces of its influence should be observed on the fœtus. The same exact effects may not, perhaps, be produced, but we are certainly entitled to calculate on some effect. The manner in which the influence of the mind is communicated to the body is not regulated by the volition of the parent, and, therefore, whenever disagreeable emotions are excited, those parts of the animal frame which are at one time disordered, would, at another, it is reasonable to suppose, be affected in a similar manner.

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* Phil. Trans. 1825, Part I., p. 75.

It is not my purpose to shew, that external objects will invariably produce the same mental disturbance, but *that there will always be a certain degree of uniformity in the consequences which succeed the operation of the same kind of feelings.* I will endeavour to illustrate this opinion by an example. A person is suddenly surprised by an occurrence which acts so powerfully on the mind, as to occasion syncope. During the continuance of the suspended or enfeebled powers of his body, great changes are invariably observed in its circulatory system. The contractions of the heart are extremely weak or cease altogether; the pulse is scarcely felt, if at all perceptible, and the countenance exhibits a pale and lifeless appearance. The emotion that has caused syncope, invariably produces these effects on the circulatory system: anger, on the contrary, increases the action of the heart to such a degree, that the pulse becomes bounding and the face flushed. *There are no exceptions to these manifestations of the intimate connexion that exists between the different degrees of depressed or excited feeling, and those parts of the system which indicate its influence.*

The same objects will not always give rise to the same evident effects in the same individual, or in different individuals from a variety of causes, which it is unnecessary to enumerate. The same intimate relation does, however, always exist, even when it is imperceptible, between the character and degree of the emotion and the corporeal organs which that emotion is capable of affecting. If the influence of the mind, has the power, as Sir E. HOME imagines, of running along the nerves to the fœtus, how does it happen that there are only a few solitary instances which seem to indicate its peregrinations? The objection arising from the paucity of cases, in which this wandering power is supposed to be apparent, he endeavours to obviate by stating, *that the nerves do not always, under the same cir-*

cumstances, produce the same effects. He would not have arrived at this unphilosophical conclusion, if he had considered, that there is a great difference between regarding an object presented to the mind, as directly the cause of the physical effect produced upon the body, or only indirectly so *by giving rise to an emotion which is itself the true and immediate antecedent to the corporeal phenomena.* According to his mode of viewing the subject, there will be no uniformity whatever in the results, arising, apparently, from the same cause, but, according to the distinction we have just made between an object viewed by the mind, and the corresponding emotions produced by it as the real cause affecting the system, there will be an invariable uniformity, both in degree and kind, between the emotion and its effects. *The external object is the cause of the emotion, but the emotion, and not the object, is to be regarded as the cause of the corporeal disorder.*

The intimate connexion which is supposed to exist between the mother and the fœtus, is not said to be accompanied by any organic provision which is capable of correcting or controlling the influence which the feelings of the former would necessarily, if such an intimate connexion existed, exert on the fœtus; the latter would, therefore, according to this hypothesis, be continually liable to be disturbed or injured by every violent state of the maternal mind, in the same manner, as the sanguiferous system of the adult is constantly excited or depressed by corresponding emotions. Instead, then, of the few solitary cases which are adduced in support of the direct influence of the mother, numberless instances of it would be continually occurring. The slightest attention to the wise and benevolent provisions of the animal economy will prove, that the greatest care has been taken to protect from external injury those parts of the system, which are the most vital in their nature or delicate in their construction. The contents of the chest are encompassed on every side by bone; the organs of sight and hearing are preserved from frequent accidents, and the brain and spinal cord are also protected by the same unyielding substance. Can we, then, suppose that the great and good Creator, who has, by these contrivances secured the preservation and welfare of his creatures, has exposed the fœtus to the injurious influence of passion, without any adaptations calculated to prevent its fatal effects? If these effects are communicated directly to the fœtus, in the same way as nervous influence is supposed by physiologists to be conveyed to different organs it appears more than probable, that females of great susceptibility in the humblest classes of society, being frequently subject to ill treatment and hardships, would seldom give birth to healthy and well formed children: yet bodily and mental peculiarities, referable to violent operations of the mind are not particularly common in the lower ranks of life. That the fœtus occasionally sympathizes with the disordered feelings of the parent, cannot, for a moment, be doubted, and I shall shortly endeavour to shew in what way it is thus influenced.

From the preceding observations it does not appear probable, that the influence of passion is transmitted to the uterus by means of nerves: though cases are frequently brought forward to prove, that when the fœtus is six or seven months old mental causes are still capable of producing great organic changes upon it. "A lady," says Sir E. Home, "in early pregnancy, was frightened by a sailor with one arm, and her child was born under the same deformity. In another, this occurred late in pregnancy: no effect was produced on that child; but in her next child, although every alarm in her own mind had subsided, the deformity was found to have taken place."*

Certain states of the mind immediately occasion an excited action of the organs of generation. If it be allowed, that the influence of violent sensations, occurring during gestation, is transmitted to the fœtus by means of the nervous connexion existing between it and the uterus, have we not sufficient reason to conclude, that these sensations, although different in kind, from those which predispose to the gratification of animal desires, are, nevertheless, created by certain states of the nerves bearing an intimate relation to the excited or depressed condition of the mind? A sensation, however widely it may differ from another in its nature and degree of vividness, is still a sensation, and cannot reasonably be supposed to possess capabilities of creating or destroying the structure of organized matter. We know that one kind of feeling will give rise to an excited action of the genital organs, and that another, will as readily depress it; but to say that a certain mental impression, communicated to the fœtus, can take off an arm, or a leg, is making it a *cutting* sensation indeed.

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* Phil. Trans., Part I. p. 78.

The resemblance which children sometimes bear to their father, in bodily form, talent, and disposition, and the diseases they inherit from him, furnish a convincing proof, that the general laws which regulate the development of the fœtus are independent of any influence of the maternal mind. Is it not improbable that a sensation of any kind should be capable of amputating an arm, or adding an extra limb?

"Tanta autem est communio," says HOFFMANN, "ut anima matris cum animâ fœtus conspiret, et nullum dubium est, quod, sensationes, perceptiones, ac passiones in matris anima excitatæ transeant quoque in ipsum infantem, sicuti id perversæ phantasiæ effectus luculenter loquuntur." The ova of oviparous and ovo-viviparous animals have no connexion whatever with the individual which has produced them, and yet a variety of dispositions and corporeal forms is observed in the beings that are produced from them, even among those of the same species: some evince great courage, others fly at the appearance of danger, some are affectionate to their young, and others are altogether destitute of affection. These facts show that fœtal existence does not require a regular flow of nervous fluid for its support and development; and, also, that the peculiarities of animal and organic life are constantly produced in circumstances, in which the imagination or influence of the parent cannot be exerted so as to modify the organization of its offspring.

We are generally impressed with an idea, that imagination acts like an independent spirit in the body; that it builds up, and takes down the organic parts of the system; converts the NEWTON, in embryo, into an idiot, and the idiot into a philosopher: in fine, that it is capable of subverting the principles of living matter which regulate the production of the diversified forms of animal life. The imagination cannot properly be considered any thing but a certain feeling, or state of the mind, which may act by means of nerves on different parts of the body; and if we endow it with the power of creating or destroying, it is, in point of efficiency, equal to those principles which regulate the formation, the nourishment, and the destruction of the whole animal kingdom.

" ESQUIROL, the celebrated French medical writer, in enumerating the causes of madness, states it as a fact, that many children, whose existence was dated from the period when the horrors of the French revolution were at their height, turned out subsequently to be weak, nervous, and irritable in mind, extremely susceptible of impressions, and liable, by the least extraordinary excitement, to be thrown into absolute insanity."*

Domestic misfortunes, and the agitated state of public affairs, occasion great alterations in the functions of the nervous system. The brain, being the seat of the thinking principle, is first disturbed, and the rest of the nervous system is afterwards injuriously affected: should it become universally deranged, and this derangement continue to be permanent, it cannot surely be deemed extraordinary that the offspring is weak, nervous, and irritable. Physiologists are not aware what are the exact contributions of the male and female towards the production of a new being; that each bestows a *something* is indisputable. This fact appears to be proved by the child occasionally possessing the diseases of both its parents.

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* COMBE on the Constitution of Man, p. 157.

It can scarcely be doubted that this *something* has a certain relation to the inherent qualities of the systems from which it is derived, and if those systems, therefore, be in an excited or deranged condition, in consequence of the prolonged injurious influence of moral causes, it is most probable that the being, conceived under these circumstances, will exhibit at least a part of the mental and corporeal disorders of the parental systems. This view of the subject is naturally suggested by a consideration of those causes, which lead to the development of the embryo, and transmit to it the peculiarities of the parents.

If physiologists had been acquainted with the mode in which the mind influences the body in cases of violent mental perturbation, they would have been less fanciful in their notions as to the influence of imagination on the fœtus. Their ignorance of one subject has tended to obscure a knowledge of the other. It has been shown in the Experimental Inquiry, that emotions, of whatever description they may be, do not disorder the different organs of the body by operating upon the nerves which belong to them, according to the opinion that has been universally entertained, *but by acting directly on the function of respiration.**

The light which this discovery has thrown on the way in which the mind communicates its extensive influence to the body, will enable us to explain the manner in which the fœtus is affected by passions of an exciting or depressing kind. Every organ of the body has certain intimate relations to the general circulatory system, and the great sources of nervous energy. From the former it derives fluids appropriated to the purpose of nutrition; from the latter, sensibility and motion. The fœtus, from its peculiar connexion with the parent, *may be considered as an organ.* If the exact relations which different organs bear to the sanguiferous and nervous systems be understood; and if it be ascertained, that to the former the fœtus bears the same relations, we shall have no difficulty in accounting for the effects produced upon it. If the corporeal organs are disordered by mental influence, indirectly communicated to them through the deranged function of respiration, the fœtus, from being similarly situated, will be subject to the operation of the same causes. If the bodily organs are not directly excited or depressed by the mind, we have no reason whatever to suppose that the fœtus is thus affected by it. Although the fœtus may be considered as an organ, yet, from its peculiar situation, and the way in which it is supplied with blood, it is less liable to the influence of mental impressions than any other part of the maternal system. Arterial and venous vessels pass directly to the liver, and, therefore, the circulation of blood in this organ will be affected by every cause that interrupts its general circulation. Violent emotions produce an instantaneous effect on the respiratory function, and this immediately disorders the sanguiferous system. In the same proportion that the natural actions of the heart and lungs are changed, the circulation of blood in the liver is rendered irregular.

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* See Experimental Inquiry, Chap. XV.

In order that the precise relations existing between the mother and the fœtus may be clearly understood, suppose an organ to intervene between the liver and its arterial and venous vessels, as the placenta does between the uterus and fœtus. In this case, the circulatory system of the liver, as a part of the general system, would be susceptible of important modifications, but to a much less extent than it is, as at present circumstanced. If the blood were propelled with greater force than usual, the impetus would not be communicated to the liver, because it does not receive its blood directly from vessels proceeding from those of the heart, but from others distributed to the intervening organs: if, on the contrary, the blood were enfeebled in its circulation, and determined by depressing emotions, to the internal organs in a greater quantity than natural, the liver would not be immediately congested, but the intervening organ would certainly be affected, because it would have the same relation to the general sanguiferous system, as the liver now has, in consequence of its connexion with the arterial and venous.

It is then evident, under the supposed circumstances, that the influence of passion would be materially lessened; but it is, at the same time, equally evident, that it would be capable of deranging the circulation of blood in the liver. The intervening organ could not, by any means, render the liver independent of the effects of sudden passions; but it might retard, for a short time, the direct transmission of them to it. If the mental emotion, which gives rise to the determination of blood to the internal organs, be lasting in its nature, or severe in its degree, the circulation of the liver will certainly be disordered, because the intervening organ will be considerably congested—a circumstance which must derange the functions of the liver. A momentary, or a slight disturbance of the sanguiferous system, may not be communicated to the liver; or, if it be, it will be to a much less extent, than if the accessary appendage were removed. These observations, with respect to the liver and its connexion with an imaginary organ, will enable us to understand the peculiar dependence of the fœtus on the maternal system, and the manner in which it is influenced by changes taking place in that system.

Although the fœtus is nourished by the blood derived from the mother, yet this fluid, owing to the intervention of the placenta, is not propelled to it with a force, equal to that with which it is carried through the arteries of the general circulatory system. If the vessels of the uterus had been of the same size as the umbilical vein, and had passed directly to the fœtus, every disturbed state of the sanguiferous system would have been communicated to it, and, consequently, fœtal existence would have been rendered extremely precarious. To obviate, therefore, the frequent occurrence of injurious effects on the fœtus, nature has wisely provided the placenta. Although this organ is of the greatest utility, yet it often happens that abortion is occasioned by violent emotions. The explanation which accounts for this phenomenon, will also shew in what manner the fœtus is influenced by less severe affections of the mind. When a woman, who is several months advanced in pregnancy, is suddenly frightened, and becomes extremely pale, or faints, the blood is determined to the internal organs in considerable quantity. This effect invariably follows the operation of depressing passions. The congestion which succeeds is not partial, but general. The placenta, as it is similarly situated to the rest of the internal organs, suffers to a certain degree with them. *The regular flow of blood to it and from it, is interrupted by its superabundance; and hence that intimate connexion existing between the placenta and uterus, during an unimpeded circulation, is disturbed, and a highly congested condition is produced, which speedily leads to the ex-*

pulsion of the fœtus. The congestion of the placenta, which occasions abortion, is also the cause of its separation from the uterus, during the course of natural labour. When the fœtus is expelled, blood still continues to flow from the mother to the placenta; and, as it cannot possibly circulate beyond it, the obvious result is, that this organ is quickly engorged; and whenever this state of the placenta occurs, the strong bonds of connexion between it and the uterus are speedily broken.

Abortion is sometimes produced by the action of drastic purgatives, and also by different diseases. From the preceding remarks, it is evident, that whatever greatly disturbs the circulation of the blood, will have a tendency to disorder the functions of the uterus in every stage of pregnancy. According to this principle, there is little difficulty in explaining the manner in which the fœtus is influenced by strong and sudden emotions of the mind. Having shewn that violent depressing passions predispose to abortion, from the great disturbance which they occasion in the sanguiferous system, it appears to follow as a necessary consequence, that feelings of a less powerful kind, will also, in a less degree, affect the fœtus through the same channel. We are by no means entitled to suppose, that their influence will be communicated in a different manner to the body, because they are less violent in their nature. On the same principle it might be argued, that the pleasurable sensation which creates a smile, differs, in the mode of its transmission, from that which occasions laughter, because the sensation is less intense. It may sometimes happen, that a sudden fright will cause great derangement in the fœtus, and yet be incapable of expelling it; the effects of the derangement being visible, perhaps, in some unnatural appearance on the child after birth: but it is more reasonable to suppose, that a disordered state of the blood will exercise a stronger influence on the imperfectly formed fœtus, than any impression made on the nervous system. The view of the subject I am here giving does not account satisfactorily for the origin of monstrosities. How is it possible for a troubled state of the circulation to create an extra limb, or an additional head? The fœtus is indebted to certain original principles of organization for its harmony of parts, and it, therefore, appears to me rational to refer the variety of malconformations which it assumes, to alterations occurring in these principles, before the organized being is fully developed. Crystals have different shapes, but yet they are susceptible of great modifications. To produce these, we must not wait until the crystal is completely formed, but must act upon it while it is yet in an imperfect state.

The whole vegetable kingdom is regulated by laws as universal and unchangeable in their operation, as those which govern the animal; though it appears to be exempt from the influence of a variety of causes, which have a tendency to disorder the production of animal life; and yet it displays a multitude of monstrosities. These cannot be ascribed to the agency of the mind, or to any condition of the nervous system, but to alterations in those principles which regulate the production of the vegetable. Animal and vegetable existence is equally derived from an *ovum:* without entering into any speculative inquiries concerning the mode of its formation, we may assert, that the peculiar organization and constitution of the future being depend on the nature and operation of the primary principles of life, and that every deviation from established laws is, moreover, to be attributed to causes which interrupt the regular action of these principles at a time when the organic parts are undetermined, or are extremely susceptible of modifications. The diseases of the mother are often communicated to the fœtus. If she has laboured under syphilis during pregnancy, her offspring frequently exhibits traces of the same disorder; or if her general health has been very bad, the child is often small and delicate. Cases are on record which prove, that small-pox and intermittent fever have been transmitted to the fœtus. "A child in utero," says Sir E. HOME, "having an ague, is itself a proof of the placenta having nerves."* There is, however, one great objection to this opinion. The paroxysms of the mother and the fœtus, in the case which he brings forward, did not occur at the same time. If they had been simultaneous, he might have affirmed, with more plausibility, that the disorder was communicated through the nervous system of the mother to the fœtus; but it is difficult to conceive how a paroxysm of the fœtus can be said to arise directly from the nervous system of the mother, when this system is in an unexcited state. The instances he adduces in support of his own views are altogether opposed to them.

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* Phil. Trans., Part I., 1825.

If a certain phenomenon had been observed in the mother, of a purely nervous character, and the same had co-existed in the fœtus, there would have been then something like probability in the supposition, that impressions of the maternal system passed through the nerves of the placenta to the fœtus. Suppose one of two balls, placed on a table, were struck, and sent in a direction proper to give motion to the other, no one would hesitate to say, that the motion of the latter was derived from the one previously hit. But, if those balls were perceived to be in action at different periods, by what kind of reasoning should we arrive at the conclusion, that the activity of the one, and the repose of the other, proved a necessary connexion to exist between them ?

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APPENDIX.

APPENDIX.

The following experiments were performed in order to ascertain, if possible, the nature of the union existing between the maternal vessels and the cord. Some physiologists are said to have succeeded in passing injections from one to the other, proving, as they imagine, a direct connexion: but so many probable sources of error have been pointed out in their experiments, that the conclusions drawn from them are little to be depended upon. At one time substances have been injected which emit a strong odour; at another such as do not combine with the blood, as oil. Mercury, and the ordinary coloured injections have occasionally been used. There are great objections to the employment of all substances, except the two latter, and these are not altogether unexceptionable. When camphor is conveyed from the maternal vessels to the placenta, it is quickly absorbed and carried with the blood into the cord or fœtus. We have no means of ascertaining the time necessary for its absorption. This will depend on circumstances with which we are imperfectly acquainted. "When a quantity of camphor" observes Majendie, "is injected into the veins of a dog, the blood soon takes a strong odour of camphor. After having made this injection into a bitch with pups, I extracted a fœtus from the uterus; at the end of three or four minutes its blood had no odour of camphor; only a second fœtus, extracted after a quarter of an hour, had a strong odour of camphor. It was the same with the other fœtuses."*

On account of the rapid absorption of substances which are sometimes injected, we are scarcely entitled to conclude, from their presence in the fœtus, that a direct connexion exists between the vessels of the uterus and the cord. The employment of mercury or the ordinary coloured injection, is not entirely free from fallacy. If the connexion between the maternal vessels and the cord is *indirect*, or in other words, if the blood which is poured into the placenta from the uterus, is absorbed by the minute ramifications of the umbilical vein, in place of circulating in a continuous current to the fœtus, it is nevertheless obvious, that those vessels which absorb, have open mouths in the direction of the uterus, whence the injection is transmitted, and, consequently, may, immediately after death, or whenever the vessels are similarly circumstanced, allow the propelled fluid to enter them. BECLARD succeeded in injecting the uterus from the vessels of the cord in a woman, who died during gestation. Experiments of the same kind have been repeatedly made by other physiologists, on the lower animals, but not with the same results. If, indeed, we grant that the experiment has been successful, in one or two instances, the positive evidence which can be produced is so equivocal in its nature, that it is wholly insufficient, in the face of numberless experiments of a contrary bearing, to establish a *direct* connexion. The arterial blood in the general circulatory system terminates in veins, and, if we consider the nature of those vessels of which the cord is formed, and the manner in which the blood circulates in them, we shall observe the same fact. The arterial blood which flows into the placenta from the uterus, is conveyed by the umbilical vein into the fœtus, and the venous blood which is poured into the placenta by the umbilical arteries, is carried into the system of the mother by the veins of the uterus.

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* Trans. by Dr. MILLIGAN. p. 508.

EXPERIMENT I.

A rabbit, about the end of gestation, was killed by prussic acid. A quarter of an hour after death, the tube of the mercurial injecting apparatus was fixed to the inferior portion of the aorta, immediately before its bifurcation into the iliac arteries. In a few minutes a great number of small vessels on the external surface of the uterus, were observed beautifully injected. The process was carried on for about three quarters of an hour, at which time it was necessary to discontinue it, in consequence of several vessels being ruptured. On opening the uteri, the maternal portion of four placenta were found considerably injected, as well as a few vessels on the fœtal portion of two of them. No mercury whatever had passed into the vessels of the cord.

EXPERIMENT II.

The object of this experiment was to ascertain, whether it were possible to inject the whole of the placenta and the vessels of the cord, with a very finely coloured composition injected from the inferior part of the aorta. A bitch, apparently within a few hours of pupping, was killed by prussic acid, and the experiment was immediately commenced. The results of the experiment were not examined till the following day. All the placentæ were most distinctly and beautifully injected. The vessels of the cord had received no part of the injection. Injected vessels were readily traced from the uterus into the placenta. The best mode of showing this, is to tear, under the water, the placenta gradually from the uterus. The results of this experiment were observed by my friends Drs. Knight and Favell, and Messrs. William Jackson, James Ray, and Samuel Gregory, surgeons.

EXPERIMENT III.

A cat, near the end of gestation, was killed by prussic acid, and left undisturbed for about two hours, it was then immersed for an hour and a half in warm water, after which a very fine injection was transmitted through the inferior portion of the aorta. Two days afterwards, one of the arteries, going from the kitten to the placenta, was injected with mercury. On examining the placenta, the fœtal portion was found to have received a considerable quantity of the coloured injection. The whole of the fœtal surface presented a multitude of small vessels of an arborescent appearance. The vessels of the cord were in a natural state. The vessels of the fœtal portion were fully injected with mercury. No connexion, however, could be traced between the two different kinds of injected vessels.

Many experiments were performed, on each of the fœtuses, to ascertain the nature of the connexion between the uterus and the cord, which are not related, because the results were precisely the same as those which are given.

In the first experiment there is nothing particularly worthy of observation, except the injected vessels on the fœtal portion of the placenta. In the second experiment, the coloured injection had succeeded remarkably well. The vessels of the cord were, however, not in the least injected. The results of the third experiment are extremely interesting. In appearance, the whole of each placenta was fully injected, nevertheless, a great number of vessels on the fœtal portion became very soon visible, on the employment of the mercurial injection, shewing that the coloured fluid had penetrated only one set of vessels.

I cannot conclude without returning my warm acknowledgments to Samuel Gregory, Esq., Surgeon, and Lecturer on Anatomy in the Sheffield Medical Institution, for his valuable assistance in these and other similar experiments.

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